ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

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Consultant: E. S. Barrows.
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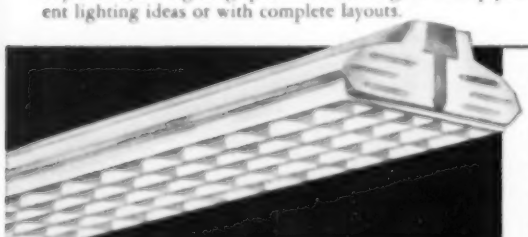
Average intensity in service: 45 footcandles.
Watts per square foot: 2.7.
Type of room: classroom.
Dimensions: 27'-6" x 40', 11' ceiling.



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ILLUMINATING ENGINEERING

THE JOURNAL OF THE ILLUMINATING ENGINEERING SOCIETY

JULY
1950

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No. 7

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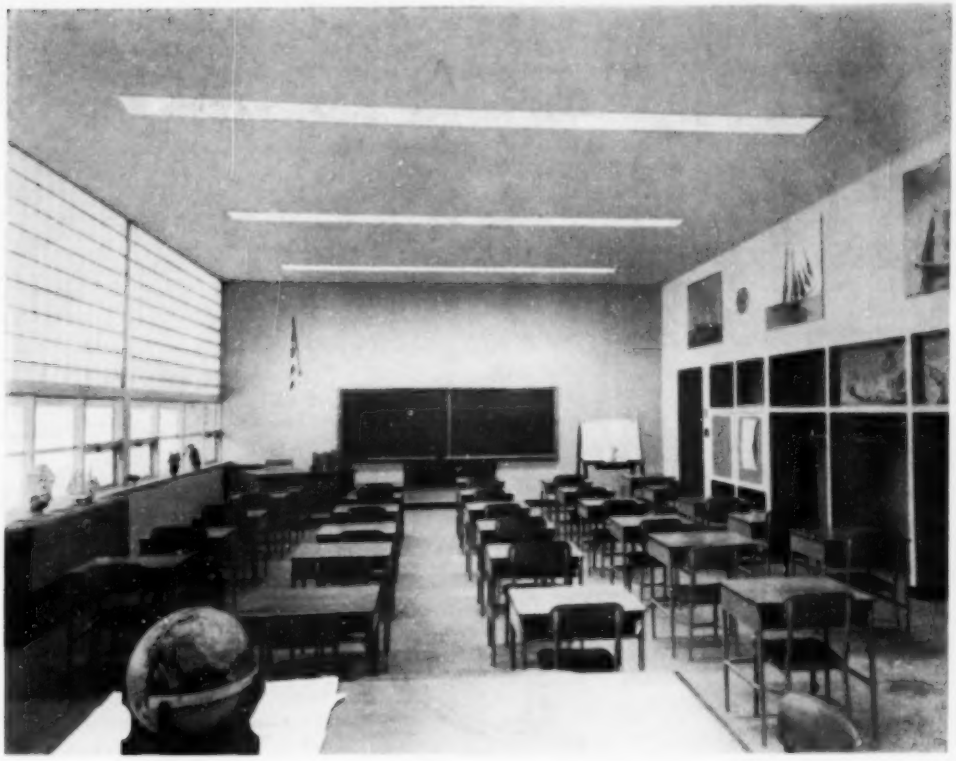


Brightness Balance in a Classroom

By RAYMOND B. McFARLAND

LIGHTING for the new South School in Rockland, Maine has been planned to achieve brightness balance rather than specific high levels of illumination. With a limited budget, the number of fixtures was held to a minimum so that the highest quality of low-brightness fixture could be installed.

The school has fifteen classrooms, one with a southeast exposure being shown here.

It is interesting to compare the brightness values used in planning the room with the actual results. These preliminary calculations were useful in proving that troffer lighting would be practicable in the schoolroom, which was doubted by some engineers. The principal objection was the usual high contrast between troffer and adjacent ceiling. In this case, the use of a high reflectance floor minimizes such contrast.

Preliminary Calculations Used for Planning:

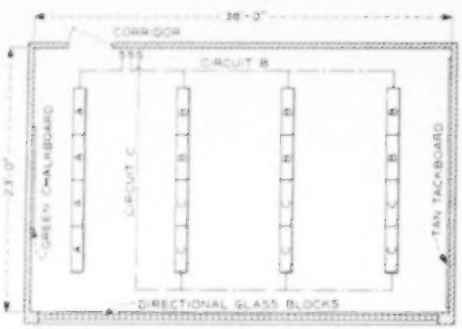
(IES Lighting Handbook, Pages 8-17)

$$E_{av} = \frac{4600 \times 16 \times .43}{828} = 38 \text{ footcandles.}$$

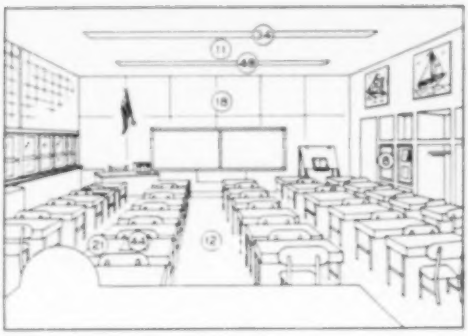
Reflectances:

task	$(r_t) = .80$	floor	$(r_f) = .30$
working plane	$(r_p) = .40$	walls	$(r_w) = .50$
ceiling	$(r_c) = .80$		

MR. MCFARLAND is Director of the Lighting Division, Central Maine Power Co., Augusta, Maine.



Classroom lighting layout.



Footlambert readings.

Planned Brightnesses:

$$B_f = 38 \times .80 = 30 \text{ footlamberts}$$

$$B_p = 38 \times .40 = 15 \text{ footlamberts}$$

$$B_f = E_{av} \times \frac{B_f}{E_{av}} = 38 \times .262 = 10 \text{ footlamberts}$$

$$B_{mw} = E_{av} \times \frac{B_{mw}}{E_{av}} = 38 \times .357 = 14 \text{ footlamberts}$$

$$M_{in} = E_{av} \times \frac{B_{in}}{E_{av}} = 38 \times .459 = 17 \text{ footlamberts}$$

$$B_c = E_{av} \times \frac{B_c}{E_{av}} = 38 \times .283 = 11 \text{ footlamberts}$$

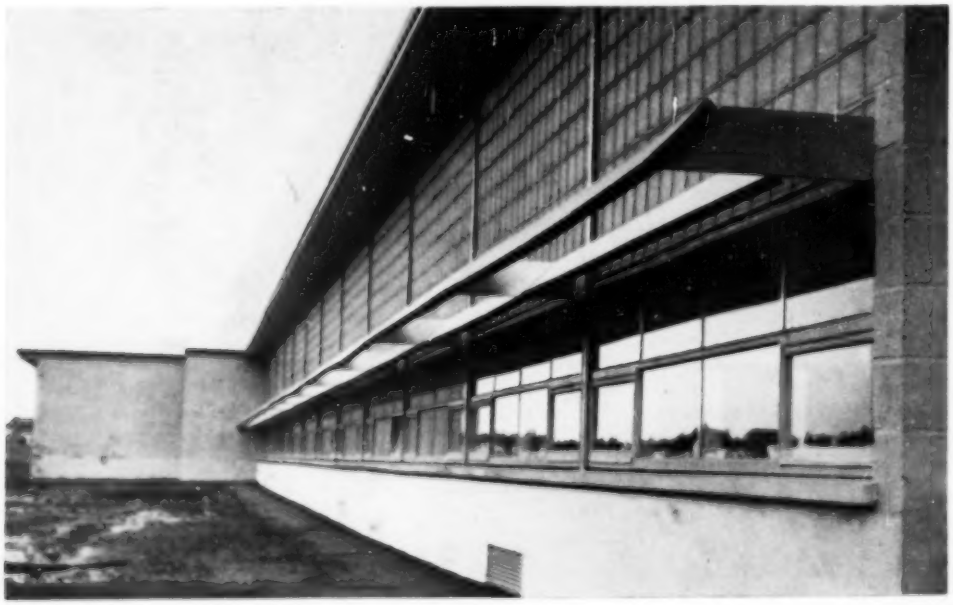
Fixture Brightnesses

At viewing angles between 0 and 45° the maximum brightness was estimated to be below 100 footlamberts. To achieve this, a sloping ceiling (not shown) was required. As a result, the fixture louvers are noticeably less effective than on a flat ceiling. In this case the rows of troffers might better have been run lengthwise in the room.

Dimensions of the room shown are 23 feet by 36 feet with an 11-ft 10-inch ceiling.

Lighting equipment employed consisted of sixteen commercially available two-lamp 48-inch re-

Exterior baffle provides daylight control for classroom.



cessed troffers, Alzak finish, using 40-watt 3500K fluorescent lamps.

The thirty-six fixed-top school desks and chairs have a reflectance of 40 per cent. Chalkboards are light green of 24 per cent reflectance. Walls, including the window wall to the floor are pale flat green, Munsell designation 57.5/7.7/4, of 54 per cent reflectance. Ceilings, of 80 per cent reflectance, have a faint green tint on acoustical plaster.

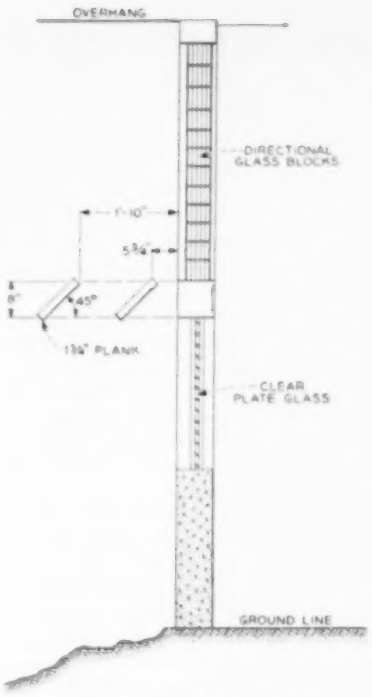
The windows of the room are of directional glass blocks with a vision strip as shown in the photograph of the interior. Daylight control is achieved by means of an exterior baffle of the type shown.

Illumination levels (taken on a dark, rainy afternoon) were:

Average natural light:	6 footcandles
Average artificial light:	36 footcandles
Total	42 footcandles

Brightness readings, taken with a Luckiesh-Taylor Brightness Meter from the rear of the room, show, for an average of three observers:

White paper on desk	44 footlamberts
Desk top	21 "
Floor	12 "
Upper sidewall	18 "
Lower sidewall	8 "
Front row of fixtures	48 "
Second row of fixtures	34 "
Ceiling between rows	11 "



End elevation, outside wall.

Acknowledgments

Eaton W. Tarbell and Associates, of Bangor, Maine, were the architects; Robert Verrier, of Portland, the general contractor; York Electric Company of Portland, were the electrical contractors; and lighting specialists were Harold Colbeth and Robert Hudson, of the Central Maine Power Company, Augusta, Maine.

Conclusion

Brightnesses of floor, walls, ceiling and fixtures are very close to predicted values. Note that the brightnesses of task and working plane are higher than the calculated values because the latter are average values. The footcandle level happened to be 51 at the point where these brightness measurements were made.

If a white paper were placed on every desk the average brightness would be about 31 footlamberts. Using this value, the brightness ratios are quite favorable, being well within 1/4 to 1 and 4 to 1.

Special Trains to Pasadena

From whatever point you're starting, to travel to Pasadena next month, don't forget that arrangements have been made with the railroads for special cars to be picked up at various points — for I.E.S. Conference Specials.

Merchandising With Light

By R. C. ALLISON

Some new angles on an old story are presented by a well-known expert on store lighting.

MAN'S BATTLE against darkness started, I presume, with the first sunset, but has carried on long past sunrise. When primitive man first came off the plains into the caves and crude mud huts he brought his treasured fire with him — not entirely for heat, but as his only weapon against darkness. In successive generations in every country of the world tools and implements have been forged to dispel darkness and break our bond of dependency on the sun as our light source.

A few years ago we stood on the threshold of success in this battle, and modern science built a huge monument to this victory — windowless factories and huge underground warehouses.

With the great developments in interior lighting in stores and factories and the ever increasing rise in illumination levels found necessary, a new problem arose — the "quality of light," and its "end use." Fine assembly work, office, storage and merchandising all require different levels and qualities.

Illuminating engineering came into its own as a science and great strides have been made in all fields. Serious studies have been made to decide how best to use the various lighting tools. The production of light is electrical engineering. The utilizing of light is illuminating engineering.

"Selling with light" is one of those interesting hybrids which combine the finer points of both parents — illumination and merchandising.

Millions of dollars are spent annually in real estate and buildings, millions are spent in manufacturing new items and new styles. Millions are spent advertising to get these products into the minds of the consumer and build up a desire to buy. Millions are spent on luminaires and lighting controls to make this merchandise seeable. These are the items that we are particularly interested in as lighting men, and it is our sole responsibility to see that they do their very important job.

We know that illumination diminishes as the square of the distance from the light source. By the same rule the usefulness of light increases as

Summary of a talk before the British Columbia Section of I.E.S. Mr. ALLISON is lighting specialist for the T. Eaton Co., Ltd., Toronto, Canadian department stores, and Vice-Chairman of the I.E.S. Committee on Store Lighting.

Figures 1 and 2. Departments on the second floor of the new T. Eaton Co. Ltd. store in Kitchener, Ontario. Recessed, louvered 208-volt, 25-cycle fluorescent units with 3500K lamps are used, on 19 x 9'6 centers, in conjunction with 200-watt incandescent units, for uniform lighting and color results. Walls throughout the store feature perimeter lighting of continuous row 40-watt 60-cycle fluorescent units in a frieze 16 inches out from the wall, to illuminate show cases and to brighten the perimeter of the store. This also serves as an excellent background for silhouette signs.

the square of the thought and care of the illumination engineer.

To consider store lighting let us look at the facts. The merchant is in business to sell merchandise. He is not selling the building, the decorations, the show cases, or the light fixtures. These are all means to an end, but he is selling and must continue to sell his goods. His lighting problems are varied:

1. The light must be useful and practical.
2. It must be directed on the merchandise in such a way either by quality or quantity as to reveal the inherent quality of the goods displayed to get quick and accurate buying decisions and reduce returns for credit.
3. The whole selling area should be inviting and cheerful. Here your most useful tool is color dynamics and you will find that paint is almost as important as electricity to a good lighting job.

The complete lighting program should be planned from the first right along with the architect, the designer and the merchandise man. Unfortunately this is not always possible. Too often lighting, one of the merchant's most important aids is tossed in at the last minute before the new or renovated store opens its doors, and a short walk in any direction will reveal hundreds of such examples — glaring examples of poor planning and waste of effort.

The principles of general lighting for stores are as varied as the styles of lighting fixtures. What might be considered perfect for one merchandiser is just the reverse for another. There is no rule of thumb or set law other than a sound knowledge of the merchants' problems.

The 1-3-5-10 theory of store lighting* is aces, but I have seen it beaten too often with a royal flush . . . cost of equipment, cost of installation, cost of maintenance, cost of operation, and just cost. I am usually content with four queens —

Quantity — Enough for a good seeing job.
Quality — An effective selling light.
Qualification — Will it do a selling job?
Quibble — Is the cost in line with the income?

It is amazing how often this hand wins when all the cards are down. So much for the theory—let's get right down to the pitfalls and problems.

Number one is, of course, the man who goes to the doctor and tells him what disease he has, how to cure it, and practically writes out his own prescription, and then gets a cheap medicine at wholesale because it cured his brother. All this without an examination or request for advice. This is the one who probably kicks most about the bill.

Another is the pre-sold job—bare lamp, daylight fluorescent or high brightness, glassware, or whatever it is you get the blame when it does not work. Your hand is called so slap down your four queens or leave the game.

It is only by constant study of merchandising problems and an intensive educational program aimed at the merchant, the architect, the designer and ourselves that we are going to achieve success in that highly technical and vastly important

*A ratio of illumination levels sometimes used in store lighting, whereby three times the general lighting (if over 10 ft-c) is specified for special displays; five times the general level for show cases; 10 times the general level recommended for niches, highlights, etc.

Figures 3 and 4. In these departments, as on the facing page, average general illumination at counter height is in the neighborhood of 40 footcandles, with wall and show cases much higher, and of course, the attraction areas higher still. Ball-socket type spot units are used for high lighting, recessed in the ceiling at predetermined areas, each with 150-watt PAR lamps. On the third floor, House Furnishings (photo at right), fluorescent general lighting was deleted in favor of incandescent only. Recessed, 200-watt square cone units with Fresnel lens on 9-foot centers are used, with high-lighting units, to create a more home-like color quality in these areas. The 60-cycle fluorescent frieze is used throughout the store.

sphere of illuminating engineering — "light for selling." So he wants "tube lights" — What is he going to sell? Women's Wear? Watch that daylight lamp! Phosphora may be the Greek Goddess of the Dawn but very few women like to be seen at that early hour. How is he selling?—From dress racks or wall cases? Well, put some light on the garments; do not bottle up all the light in the case; consider the dressed case when you light it, not just an empty box. Jewelry? Diamonds fall pretty flat under fluorescent or indirect, better add a dash of point source incandescent to improve the sparkle. Examine him, study his symptoms, diagnose his case, and then, and only then, write your own prescription of a cure, and it is not always the expensive drugs that do the job; but don't just give him an aspirin to make the sale. There are too many "snake oil" doctors in the lighting field already and we are the medical society of lighting. We must strive to cure the diseases to earn the respect our society deserves. One more point — many drugs have a serious after-effect so do not use a method of curing his particular disease if the after-effects of such method leave him in worse pain — a sea of fixtures, exhorbitant power and maintenance bills and lack of flexibility.

Pitfall No. 2 is the remodeling and renovating job. Many merchants today, due to the stress and strain of modern merchandising, are spending considerable money in the building and renovation of their business locations. In the past ten years a not too gradual change has taken place in the minds and work of store designers and architects and a more startling change has taken place in merchandising technique and store lighting. Self-service and like merchandise presentation have completely revolutionized showcase design and store layouts and have demanded very special treatment in lighting technique. Where low lighting levels of general illumination were acceptable 40 years ago, the tempo, merchandise methods and layouts and seeing needs have changed so completely that in competitive areas today in modern store design the minimum general lighting is considered to be between 30 and 40 footcandles.

Probably the greatest single factor affecting modern store layouts, show case design and especially lighting, is the customer herself. The trend of direct customer sales person merchandising has almost disappeared except perhaps in a few very exclusive jewelry or name dress salons. A good 97 per cent of goods sold today are sold through the customers' eyes. She must be able to see to choose and choose to buy. The basis then of merchandise presentation is eye appeal. Advertising in newspapers and magazines is designed for eye appeal; show windows and interior displays are designed and lighted for eye appeal. Show cases, wall cases, and wardrobes are designed and lighted for seeing what you have to sell, its approval and actual purchase. The general layout of the store, the general lighting technique and color schemes are chosen to direct the customer in a pleasant atmosphere by leading her eyes from one point of interest to another, to create the urge to buy, to complete the transaction through her visual appraisal.

In a large sales organization I venture to say that over 50 per cent of the customers that come in and shop never speak to a clerk unless it is absolutely necessary to complete the sale. Therefore it is extremely important to aid this shopper on an eye tour of the merchandise. It is from her visual acuity that she sells herself on the finer points and qualities of the merchandise displayed.

Pitfall No. 3 is partial renovations. Since it is not always possible to close a place of business to make a complete renovation of the area, many firms carry on a gradual improvement in which case only certain portions or departments are renovated at any one time. This may be in the small butcher shop where the merchant has installed a new refrigerator case, so he wants to clean up the general appearance of the area surrounding this new case. A little later the modern merchandiser may plan to improve more and more of his general floor space until his final tie in with lighting or paint, or maybe a new store front completes the face lifting job. This may be carried on over a period of months or even years. The one most important factor to any long term contract of this type is to consider if possible the whole move, and then each little section as it is finished will fit as pieces of a jig saw into the whole puzzle.

Many kinds of store improvements will contribute to the complete modernization plan — fixtures, display cases, store rearrangement to take advantage of traffic flow, air conditioning, cheerful floor coverings and color dynamics. These are all essential parts of every modernization plan which will be enhanced by well-designed lighting.

Since most modernization appears to be a continued activity, it becomes evident that a master plan of lighting must be prepared and worked toward. The aim in lighting design will be to step up the actual selling power of the store by designing and directing the lighting on to the merchandise to make it more attractive, easier to find, and easier to buy, which will, the merchant hopes, achieve the basic objective—greater volume of sales per square foot, per sales person, per dollar overhead.

Lighting for a Den

LIGHTING OBJECTIVE: (1) To provide in a small low-ceiling room illumination for casual reading and card playing.
(2) To provide soft background lighting for conversation and evening entertainment.
(3) To provide decorative lighting at the fireplace.

Installation at Detroit, Michigan

Interior decorator: Valerie Stevens **Architect and builder: Mark Atkin**

General Information: The room is 10 feet by 11 feet 5 inches, with a 7-foot ceiling. The walls are panelled in cedar (20% RF) and the fireplace is made of fieldstone (63% RF). Inlaid tile, deep green with a tiny white fleck (45% RF), covers the floor. The davenport is upholstered in a rough cotton fabric in bright red and the leather chair and foot stool are the same color. The draperies are made of a heavy lined cotton fabric. The leaf design in chartreuse and green with touches of maroon is set off against an oyster white background. These colors are very clear and form a rather splashy design. The slip cover matches the draperies. The CLM table lamps have green leather bases and green opaque shades. The plaster ceiling repeats the oyster white (80% RF) in the draperies.

(over)

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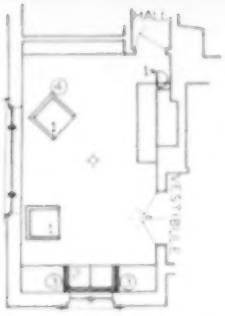
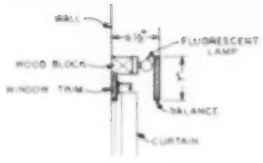


Plan view: (1) chair, (2) davenport, (3) table lamp, (4) floor lamp.



Section through window valance.

Installation: Three excellent reading positions are provided in the room. The CLM end table lamps, placed close to the edge of the built-in end tables, provide comfortable levels of light for reading when the 150-watt filaments are used. Both lamps are controlled by the same wall switch and consequently are always used together. The opaque shades blend well with the fairly dark background and the direct light from the valance further lessens the contrast. A 63-inch floor lamp with a 10-inch reflector, light tan translucent shade and 100-200-300 watt lamp is used to one side of the leather chair. Bridge table lighting is provided by a close-to-ceiling fixture with an opal glass bowl and four 40-watt lamps. This fixture (Appleman Co. No. 46/254) is switched from either entrance to the room.

Behind the davenport and over the windows is a 54-inch valance board concealing a 40-watt 3500K fluorescent lamp. The window valance directly opposite the fireplace is 8 feet 6 inches long and conceals two 40-watt 3500K fluorescent lamps. These valances are direct-indirect and extend 7 inches out from the wall. Thus the light is well distributed over the draperies; at the same time it is directed toward the ceiling giving a decoratively pleasing effect.

To provide some decorative lighting at the fireplace side of the room, an 8-watt portable fluorescent lamp unit is concealed behind a long narrow planted dish on a 4-inch projecting ledge (see photo above); an extension cord to a nearby convenience outlet is fitted into a mortar groove of the fireplace. The resultant soft glow silhouettes the green plants and forms interesting shadows on the ceiling.

Illumination levels are as follows:

Average in room (floor and table lamps, valances, and ceiling fixture)	15 ft c
Reading position at end of davenport (150-watt table lamp only)	18 ft c
Reading position at davenport (valance and 150-watt table lamp)	26 ft c
Arm of davenport (valance and table lamps)	46 ft c
Table under table lamp	40 ft c
Bridge table under ceiling fixture	9 ft c

Brightness readings:

Lamp shade	2.5 ft L
Wall	3.0 ft L
Floor	1.0 ft L

Lighting data submitted by Mrs. Marquita Dygert and Miss Mary Tarpke, The Detroit Edison Company, as an illustration of good lighting practice and to aid in the design of similar installations.

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Humidity Effect on Instant Starting of Fluorescent Lamps

By R. H. McFARLAND
T. C. SARGENT

Instant start circuits for initiating the arc discharge in fluorescent lamps are desirable from the consumer point of view but present more technical difficulties than the conventional starter-type circuits. The absence of an inductive surge or high voltage transient in the instant start circuit makes it necessary to have a higher initial voltage potential to start the arc. External inhibiting conditions may interfere with the ease of starting. Humidity is a major example of such an inhibitor and the humidity effect is described in this paper. Some phases of the work covered by this report have been corroborated by others.[1,2]

INSTANT starting of a fluorescent lamp infers little delay between the time that the lamp voltage is applied to the tube and the time that the arc is struck. Since this does not permit heating of the cathodes which is done in conventional fluorescent lamp starting, much higher voltage potentials must be applied to the lamp in order that ignition may occur. These potentials may be applied and the arc operated with an electrical circuit similar to that of Fig. 1.

To understand better the principle of high potential starting, one can investigate the voltage-current characteristics of a typical arc discharge such as that of a 48-inch 40T12 lamp, shown in Fig. 2. When under normal circumstances the voltage across the lamp is increased slowly the lamp goes through at least three distinct stages. These are represented by separate portions of the curve *ABC* of Fig. 2. As the potential difference across the lamp reaches an RMS value of approximately 185 volts, small brush discharges emanate from the electrode. The current at this time is exceedingly small, not in excess of a very few microamperes peak value. As the voltage is increased to a region of 200-220 volts, a glow discharge (A) fills the lamp. As the voltage is increased further to 250-300 volts, a condition is reached where the discharge becomes a self-sustaining arc (B) due to the combined effects of all emission producing activities. With the resultant change in cathode potential drop, the voltage-current curve becomes one with a negative slope. In this region, *C*, the lamp is operated with the aid of a series impedance. The potential difference across the impedance plotted against the current approximates the curve *DE*.

Under abnormal circumstances, due to discharge inhibiting conditions which will be explained later, it is quite possible for the lamp's atmosphere to remain nonconducting until some point *H* is reached. Then the arc is struck almost instantaneously with-

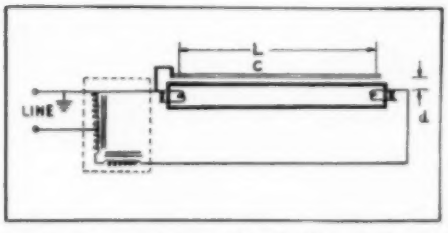

Figure 1. A schematic circuit for operating a single 40T12 instant start lamp.

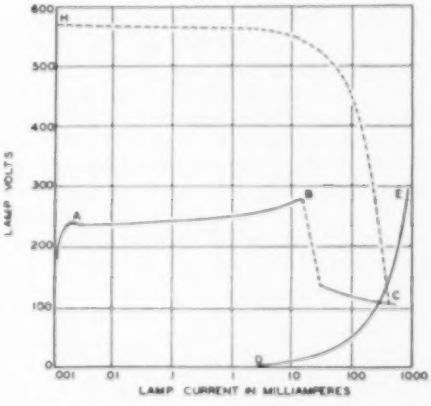

Figure 2. The voltage current characteristics of a single 40T12 instant start lamp.

A paper presented at the National Technical Conference of the Illuminating Engineering Society held September 20-23, 1949, French Lick, Indiana. Authors: Kansas State College, Manhattan, Kansas and Sylvania Electric Products, Inc., Salem, Mass., respectively.

out the intervening glow discharge becoming apparent.

If a non-inductive resistance is in series with the tube, the lamp potential can be calculated to follow the curve *HC*. This entire region, however, is unstable; and the lamp potential drops rapidly from *H* to its stable operating value at approximately 108 volts. It is known that starting potentials vary over a wider range with change of humidity than with changes of other parameters external to the discharge tube upon which they are dependent.

In order to start a fluorescent lamp from an inactive status to that of a normal operating condition, two requirements must be met:

1. The gas between the electrodes, which is ordinarily a good insulator, must be made conducting.

2. The cathodes must be conditioned to furnish sufficient electrons to maintain a self-sustaining arc.

While minimum cold starting potentials of fluorescent lamps are determined entirely by the construction of the lamp itself, external conditions play a large part in determining the actual starting potentials. The physical characteristics such as dimension, type of electrodes, type and pressure of fill gas and impurities in the gas all contribute to determine the minimum values which it is possible to attain for points *A* and *B* in Fig. 2. At the same time, external conditions exercise a large influence in determining the value of *H*. These are: grounding, capacitance, temperature, and humidity conditions.

Grounding and Capacitance

In attaining the first prerequisite of starting, that of causing the gas to become conductive, it is important that as high field strengths as possible be built up in the gas. Under normal conditions, lamps operating from an autotransformer with the proper side of the line grounded, as shown in Fig. 1, have one of the lamp cathodes held at ground potential while the other cathode is operated at a potential above ground equal to the applied lamp voltage. Any capacitive body, such as the grounded conductor *C*, imposes the full applied potential across the short distance *d* from the ungrounded cathode to the conductor. Since *d* is much shorter than *L*, the voltage gradients become proportionately greater to initiate the gaseous breakdown. If all capacitive objects are removed from the vicinity of the lamp, the initiation of the discharge must arise only from the potential applied between the two ends of the lamp. Fortunately, the starting potential required in that instance does not bear the same ratio to the starting potential with a conductor or other capacitive body as does $\frac{L}{d}$ because of the tendency of a gas to withstand higher potential gradients in a short gap than in a long gap.[5]

To test the effect of a grounded conductor, a group of 40T12 lamps were suspended by two threads so that they were at least 6 feet from the nearest object. Starting tests showed that lamps suspended in this manner started at potentials approximately 10 per cent greater than when a grounded conductor or other capacitative body was placed close to the bulb. At high humidities, however, the increase in starting potential without the conductor is much greater.

Since switching surges were unpredictable, the lamp voltage was increased at a regular rate with minimum surges. This was accomplished by connecting a back-geared motor to a Variac in the line-side of the lamp transformer. A special clutch released the Variac at any time desired. A current activated relay in the lamp circuit stopped the motor at the moment of ignition. Starting voltages were read just prior to the time of starting with an RMS voltmeter connected directly across the lamp.

In general, the higher the minimum starting potential for a given lamp the less necessary is a special capacitive body. Lamps which have normal minimum cold starting voltages above 500 volts because of their physical dimensions have less need for conductors than do easier starting lamps. In this instance one of the cathodes is so far above ground that it is relatively easy for the potential gradient to become distorted enough to initiate the discharge. The phenomenon is also apparent in series operated groups of lamps, for it is seldom that any starting aid is needed in such a circuit even though the available starting voltage for the group may be less than the sum of the minimum starting potentials of the individual lamps in the group.

Humidity and Temperature

Although numerous attempts have been made to start fluorescent lamps instantly, all of them have been unsatisfactory until recently because of erratic starting behavior. Undoubtedly the largest external inhibitor of lamp starting by high potential means is humidity.

Controlled tests were run to indicate the extent of the humidity effect. 40T12 lamps were selected which were constructed under as nearly identical conditions as possible and whose normal low humidity starting potentials were alike. The lamps were operated in a humidity-temperature cabinet in which it was possible to automatically control both humidity and temperature. All lamps were mounted in a grounded metallic fixture during the tests. The average a-c cold starting potentials of 12 lamps measured with an RMS voltmeter and

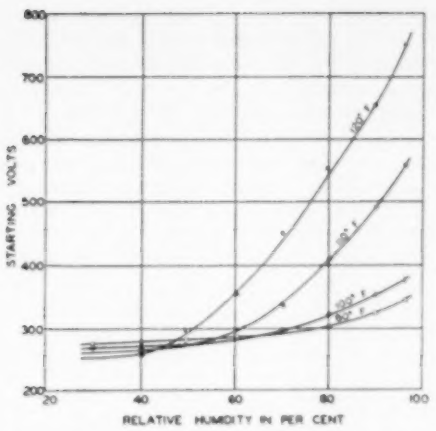

Figure 3. Starting voltages of 40T12 instant start lamps *vs* relative humidity.

plotted against relative humidity are shown in Fig. 3.

A second set of curves in which absolute humidity is the independent variable are shown in Fig. 4. It is this latter group of curves which is most interesting, for it shows most clearly the dependence of starting potentials on the temperature and humidity of the air to which the lamp was exposed. Increased absolute humidity produced increased starting potentials while increased temperature at constant absolute humidity over the range at which these measurements were made produced a decrease in starting voltage. Lamps whose physical dimensions are long and slender such as are encountered

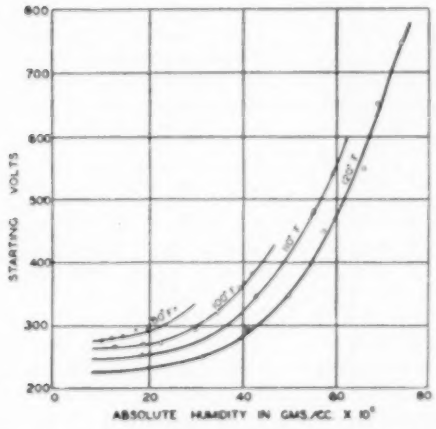

Figure 4. Starting voltages of 40T12 instant start lamps *vs* absolute humidity.

in the T6 and T8 long slim lamps may actually show a ten per cent increase in starting voltage as their temperature is increased from 80 to 120 degrees F. Long slim lamps filled to higher than normal pressures have smaller temperature effects but higher normal minimum starting potentials.

Surface resistance and starting potential measurements were made on a lamp under conditions such that surface resistance could be made to vary. For large surface resistances, this was accomplished by taking measurements in the humidity cabinet. Variation in humidity caused the necessary variation in surface resistance. Lower surface resistance conditions were obtained by immersing the lamp in solutions of different conductivities or by painting the lamp with conducting paints.

The data obtained are plotted with starting voltage versus surface resistance to form Curve *A* of Fig. 5. This shows lamp surface resistances between

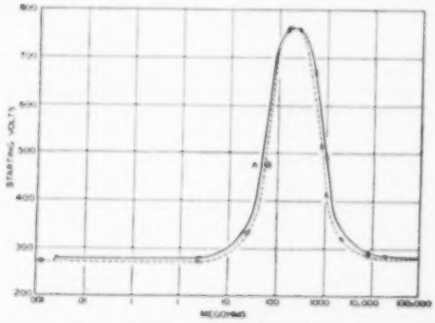

Figure 5. Curve *A* indicates variation of starting voltages of 40T12 I.S. lamps with changes in surface resistance as a consequence of varying surface moisture. Curve *B* indicates variation of starting voltages in surface resistance of the lamp in Fig. 6 as a consequence of changing the magnitude of the resistors, *r*, when R = ∞.

5 and 10,000 megohms are accompanied by increased starting potentials. The maximum starting potential occurs at approximately 300 megohms. These results confirm previously published work.[3] These investigations coupled with others in which lamps were started when immersed in liquids of different conductivities led to the following conclusions:

1. The humidity effect is caused by a water film being in direct contact with the glass envelope.

2. The moisture in the atmosphere between the lamp and the reflector has negligible effect if any at all.

3. The humidity effect causes a delay in the initiation of conductivity of the lamp gas.

4. The leakage from lamp pins, along the lamp, ordinarily has a negligible part in the humidity effect.

Simulation of the Humidity Effect

Since measurements made in a humidity box do not allow rapid changes of circuit or ready measurement of small currents and potentials, an experimental lamp was wrapped with numerous bands of metallic foil which were separated from each other by small air gaps. By connecting the bands with various sized resistors, it was possible to simulate the effect of a capacitive coating with various values of conductivity such as is set up by water on the lamp surface.

A schematic diagram of the lamp as well as the starting circuit is given in Fig. 6.

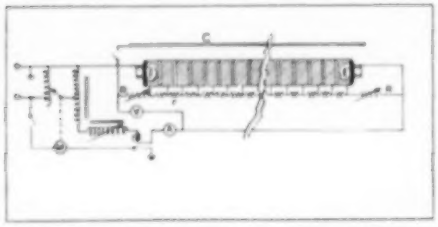

Figure 6. Special circuit used for starting 40WT12 I.S. lamps and producing controlled lamp gradients.

The close approximation of the banded lamp to one affected by humidity is shown in Fig. 5. Starting voltages plotted against surface resistance of a lamp when the humidity of the air is varied produce Curve *A*.

Curve *B* represents starting voltages which are obtained when the total resistance across the banded lamp is varied by changing the values of *r*. The small departure of cure *A* from curve *B* is no more than would be expected between different lamps of the same type.

Prevention of the Humidity Effect

Curve *A* of Fig. 5 indicates two of the methods by which the humidity effect may be overcome. It can be seen that the lamps start with little difficulty if the surface resistance is below 15 megohms or above 1500 megohms. Therefore, the lamp surface may be made conductive or it may be made to have a highly resistive coating under more humid conditions. Either of these methods is effective in reducing the humidity effect. Another method which may gain future importance is the use of an internal conductor along the length of the tube.

1. *Use of Conductive Coatings*

Any material which can be applied to the outer surface of a lamp which will tend to lower the surface resistance to the order of a few thousands of ohms per inch will materially lower the high humidity starting voltage. This beneficial effect is brought about by limiting the potential that can be built up across the lamp by the small capacitive currents.

Unfortunately, most materials for such application which conduct electricity well are opaque. Tin chloride has probably greater transparency than any of the other materials now in use. In application, the tin chloride is applied as a vapor to the hot glass before being made into a lamp. When the lamp is designed for high operating voltages, the coating is preferably internal, to reduce shock hazards. At the present time cost of application and iridescence of the coating have tended to discourage its use to prevent the humidity effect.

2. *Use of Conductive Stripes*

Many experiments have been performed with conductive stripes of various widths. Ordinarily the stripe was about 1/16" in width and extended parallel to the length of the lamp from a point near one cathode to a point near the opposite cathode. In most cases the stripe was not grounded. While some improvement in lamp starting may be achieved with use of such a stripe, the humidity effect is still evident. 40T12 lamps which normally start at potentials under 300 volts may require more than 500 volts under high humidity conditions even with this external stripe. This is higher than would be expected. However, it is thought that that reason for the additional necessary voltage lies in the small capacitive area which the stripe presents to the cathode as compared to the much larger area presented by the moisture on the remaining lamp surface. Currents flowing to the water film must flow through a high impedance before reaching the shorting stripe. This tends to increase the potential drop across the lamp and increase the required starting voltage. Increasing the area of the stripe near the cathodes tends to lower the starting voltage. Grounding the stripe has the effect of increasing the capacitance of the stripe. With the stripe grounded, no humidity effect is experienced.

3. *Use of Highly Resistive Coatings*

Organic waxes used in preliminary experiments to protect lamps from moisture were effective but easily destroyed. Successful attempts to insulate occurred only after silicones became available. At the present time, silicone film[4,5] deposited on the outer surface of the lamp acts effectively to disperse moisture tending to collect there. This prevents a capacitive film from forming and keeps the resistance of the lamp surface well above 1000 megohms. With impedance paths of this magnitude, the tendency of such capacity currents as are set up to cause uniform potential gradients are made

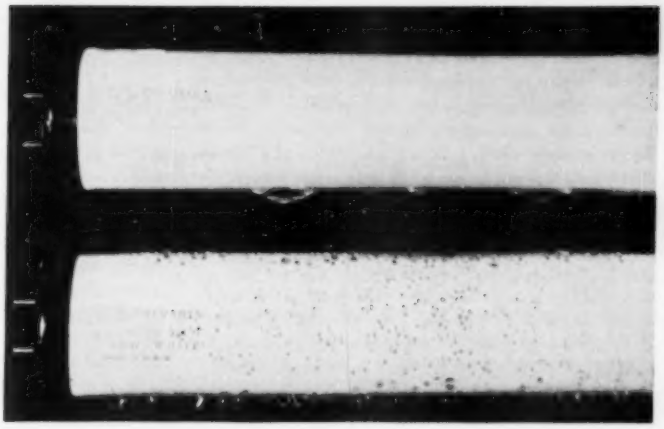

Figure 7. Comparison of the effect of humidity (moisture) on an untreated lamp (upper photo) and a silicone treated I.S. lamp (lower photo). Large drops collect on the untreated lamp surface. The hydrophobic silicone coating of the treated lamp has isolated droplets. The resulting high surface resistance is sufficient to minimize the humidity effect.

ineffective by the lower impedance path from any capacitive body to the ungrounded cathode and lamp surface. Siliconed 40T12 lamps which ordinarily start at an average minimum potential of approximately 275 volts have starting voltages of less than 300 volts when started at 100 per cent R.H. and 120° F. without a grounded reflector. The hydrophobic effect of silicone coatings is seen in Fig. 7.

Some advantages of silicone coatings over other methods of reducing the humidity effect are transparency, permanence, and freedom from shock hazard. Properly applied silicone coatings are smooth and more easily cleaned than is untreated glass.

Large numbers of siliconed lamps have been placed in field tests under various conditions which were judged detrimental to the silicone surface. Periodically a portion of each test of lamps were carefully removed from their location and returned to the laboratory for testing the quality of the silicone coating as well as the effect of deposited foreign material on the lamp surface. Although dirt may collect heavily on the lamp surfaces, the resulting high humidity starting voltages are lower than would be expected from clean striped lamps under similar humidity conditions. Lower starting voltages for very dirty siliconed lamps are aided by a grounded reflector.

Starting of Direct Current Lamps

Repeatable starting potential measurements on direct current lamps are much more difficult to make than is the case with alternating current operation. Humidity has little effect on the starting process.

Identical 40T12 lamps such as have been used in the foregoing experiments may be found to have d-c starting voltages of from 1800-2000 volts when the applied lamp voltage is increased slowly as was done with a.-c. lamps. Abruptly applied d-c. potentials, however, cause lamp starting at potentials of the order of 300 volts.

Summary

The major external inhibitor of high potential instant starting of fluorescent lamps is humidity which produces leakage paths along the lamp surface. These paths may be reduced by the use of silicones or by the use of conductive areas which increase the potential gradients at the cathode by decreasing the drop along the lamp due to leakage currents.

Acknowledgment

Acknowledgment is made to Dr. J. G. Winans of the University of Wisconsin and to the General Engineering Laboratories of Sylvania Electric Products, Inc. Some of the contents of this paper were submitted as partial fulfillment of requirements for the Ph.D. degree at the University of Wisconsin.

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DISCUSSION

D. D. Hinman*: The authors confirm the previously reported relation between lamp starting volts and surface conductivity of the bulb as well as the efficacy of silicone treatment and transparent conductive coatings in reducing the humidity effect. However, they find that a $\frac{1}{8}$-inch wide conducting stripe has insufficient capacitance to be fully effective unless it is grounded. Although lamps with a floating (i.e. ungrounded) stripe may require a slightly higher voltage to start than the minimum attained with a grounded stripe, any surface conductivity of the bulb at high relative humidities tends to increase the effective capacitance of the stripe and lower the starting voltage. Many laboratory tests have shown a decrease in the starting voltage of striped lamps when the relative humidity is increased. The commercial application, for several years, of both stripes and silicone treatment has demonstrated that both methods are generally effective in preventing lamp starting difficulty under high humidity conditions.

Robert H. McFarland**: In reply to Mr. Hinman's discussion it should be made clear that the information of the preceding paper in its entirety is meant to apply only to the conventional 40T12 lamps. Prior to the time this paper was first written, 1946, every effort was being made to develop instant starting lamps with as great an efficiency, including low cost, as possible. This created a need for lower open circuit ballast voltages. In the resulting work wider ranges in ambient conditions were investigated in order that an insight could be obtained concerning the mechanism of the humidity effect. The results of this work reported in reference 6 of this paper proved conclusively that the cause of the humidity effect is a redistribution of the potential across the lamp by leakage "capacitive" currents along its outer surface.

The author is in perfect agreement with Mr. Hinman in his statement that either the striped or siliconed are generally effective with the present 450-volt ballast. As a matter of fact, he has such an installation using untreated lamps which has never failed to start in the past few years. However, if the ballast voltage were to be made 350 volts, then only siliconed lamps would be proficient as indicated by Table II of reference 2 in which Mr. Hinman and Mr. Thayer show that 450 volts are required to start 100 per cent of lamps tested at 80°F.

Actually, it has been shown possible by proper ballast design to start instantly 40T12 lamps, silicone treated, with voltage as low as 225 volts and with ambient conditions as bad as 120°F and 100 per cent relative humidity.

Finally, since this has become a resumption of the discussion which was appended to the paper of reference 2, I should like to clarify some of the points made by Mr. Hinman and Mr. Thayer at that time in their final discussion.

1. The experiments from which the author determined the relative merits of striped versus siliconed lamps without the benefit of nearby capacitive objects included a series of tests in which clean and dirty siliconed and striped 40T12 lamps were suspended by their lead wires from the ceiling of a temperature and humidity controlled room. Test lamps were suspended such that the lead wires made an angle of 135° from the surface of the lamp. No objects other than the wire approached the lamp closer than eight feet. Humidities ranged up to 100 per cent at 120°F. Under these conditions siliconed lamps were observed to have up to 335 volts starting potentials while ungrounded stripe lamps had starting potentials up to 550 volts. Somewhat better starting results are observed with both types of lamps in grounded fixtures under high humidity conditions.

2. Figures 3 and 4 of the present publication are meant to justify a previous statement to the effect that the humidity effect is one best associated with absolute humidity and is not a linear function of relative humidity. Further, even for constant temperatures, the effect is not a linear function of relative humidity. The author did not intend to imply that plotting electrical resistance against relative humidity as was done by Littleton and Morey is impractical for conditions such as theirs but that an absolute humidity curve for starting potentials is more informative. Separate curves corresponding to different temperatures should be observed when plotting starting potentials against absolute humidity because of the inherent effect of temperature on lamp starting.

3. The use of dinnerware as an example of the abrasion resistance of metallic stripes is invalid in this connection as the glaze covers the dinnerware stripe, making it nonconducting. With all the dishware available in 1946 the metallic stripes were all nonconductors even when the outer glaze was removed.

4. The author did not intend to include R. F. lamps in this discussion as they are more nearly like d-c lamps which are relatively immune to the humidity effect.

5. In conclusion, it is desirable to again call attention to the five reasons listed in reference 2 which, along with the fact that siliconed lamps rectify the humidity effect more effectively than does an ungrounded $\frac{1}{8}$-inch stripe, has led the author to choose silicone coating as the most desirable preventative. These are probably similar to those recognized by the industry which uses silicone coatings on a large majority of the instant starting lamps now produced. These reasons were:

1. Silicone coatings are permanent while conductive stripes are relatively easily abraded which tends to destroy their effectiveness.

2. Silicone coatings are completely transparent. This eliminates the necessity for any special orientation of the lamp as is needed with striped lamp.

3. Silicone coatings offer no shock hazards.

4. Siliconed lamps operate equally well on series or multiple circuits which eliminates the need for two separate lamp types.

5. Properly applied silicone coatings are smooth and more easily cleaned than is untreated glass.

*General Electric Co., Cleveland, Ohio.

**Author.

The Discoloration of Veal Loaf When Exposed to High Level Illumination

By HUGH ARCHER
R. E. BANDFIELD

Discussing an investigation of lighting factors which produce discoloration of veal loaf. Samples were exposed at temperatures ranging from 33-65F to both tungsten and fluorescent light sources at levels of 50 to 150 footcandles, and the time required to produce the least perceptible discoloration was observed. The results indicate that the time for least perceptible discoloration is a function of temperature, light level and spectral distribution. The use of various filters between the light source and the meat indicate that the shorter wavelengths of light caused discoloration faster than did the longer wavelengths.

THE FADING of materials when exposed to light has been observed by numerous investigators.[1,2] Their conclusions generally state that the fading is a function of footcandle-hour exposure. Recent successful efforts of experts in the lighting field to increase light levels for selling purposes in meat markets have revealed the unhappy circumstance that a high illumination level accelerates the discoloration. The resultant customer dissatisfaction cancels the sales stimulation of high light levels.

Field inspections of meat discolorations revealed that the difficulty was usually in a modern "super market" type of store. Light levels on meat counters varied from 35 to 100 footcandles using fluorescent lamps. Conversations with the butchers in this type store usually included their mention that "we never had this trouble before."

An inspection of the literature gave no quantitative information on meat discoloration by exposure to light. It was decided, therefore, to observe, in the laboratory, the effects of various light levels as a starting point in an effort to understand the problem.

The nature of the experiments reported herein is therefore exploratory. No attempt has been made to explain the phenomenon although some effort has been made to investigate means for reducing the discoloration by selective filters.

Though the butchers reported that the discoloration took place on all prepared meats, they stated (and preliminary work confirmed) that veal loaf was the most sensitive in its response to light. Fresh killed meats also showed the effect, but some confusion in observation resulted from dehydration effects. It was consequently decided that veal loaf would be used as the sample.

Technique of Observation

The meat was observed under various levels of illumination from both tungsten and fluorescent sources. The meat temperature was controlled over the range 33F to 65F. A non-spiced, finely ground, cooked veal loaf was used. Each sample comprised two slices, cellophane wrapped. The spectral transmission of the cellophane was measured and found to be constant at 90 per cent from 3500A to 10,000A.

The information determined was the time required at constant temperature and illumination to produce the least perceptible discoloration of the sample. Five different observers and approximately 200 samples of meat were used in the tests. The meat samples were prepared from freshly prepared whole veal loaves. Control samples were observed from each prepared batch of samples to check uniformity. The exposure necessary for least perceptible discoloration determined in control sample cases agreed to within 20 per cent. The newly prepared samples were preserved at 32F and in the dark.

The level of illumination was measured with a calibrated footcandle meter with corrections for its response to color quality of light.

The various temperature levels were obtained by the use of a temperature-controlled room. Meat temperatures were observed by inserting into the

The authors are Senior Research Engineer, Electrical Div., Research Dept., and Ultraviolet Specialist, Lighting Sales Div., Sales Dept., of the Detroit Edison Co., Detroit, Mich., respectively.

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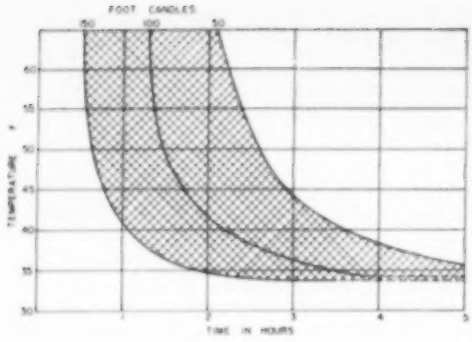

Figure 1. Time for least perceptible discoloration in veal loaf. Light source—tungsten, 100-watt. No filter.

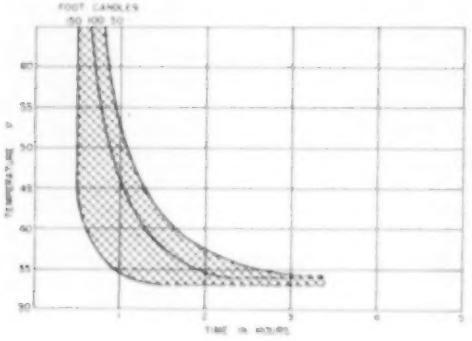

Figure 2. Time for least perceptible discoloration in veal loaf. Light source—fluorescent, 20-watt white. No filter.

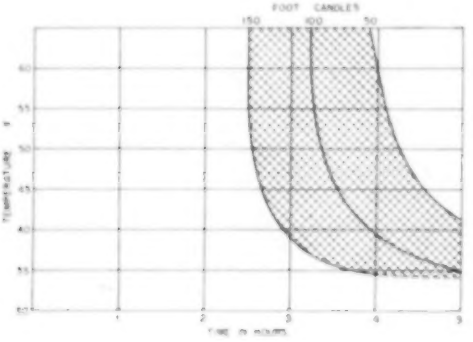

Figure 3. Time for least perceptible discoloration in veal loaf. Light source—20-watt white fluorescent, with Noviol "C" 2.05 mm filter.

TABLE I.

Light source	Filter	Illumination level, footcandles	Temperature, F	Figure No.
Tungsten				
100-w.	none	50	32.65	1
"	"	100	"	
"	"	150	"	
Fluorescent				
20-w.—white	none	50	33.65	2
"	"	100	"	
"	"	150	"	
Fluorescent				
20-w.—white	Noviol "C"	50	33.65	3
"	2.05 mm	100	"	
"		150	"	
Fluorescent				
20-w.—white	Catavar 1001	50	33.65	4
"		100	"	
"		150	"	
Fluorescent				
20-w.—white	Commercial	50	33.65	5
"	filter sold	100	"	
"	for purpose	150	"	
Fluorescent				
20-w.—white	Tenite I	50	33.65	6
"	Amber acetate	100	"	
"	Color 7695	150	"	

ment an iron-constantan thermocouple of No. 30 Awg wire. Temperature measurements indicated no perceptible difference in temperature across the surface of the meat samples.

The discoloration was made more apparent by the use of an opaque shield placed on one half of the sample during exposure. Dehydration was prevented by the cellophane envelope. No difficulty was experienced in obtaining comparable data between the different observers. Each sample was observed independently by more than one observer as a means of increasing reliability of data. The "as received" color of the veal loaf showed a pinkish-tan appearance. Upon exposure, the principal color change noted was a reduction in the "pink" component. This left a greyish-tan appearance to the meat surface. No other change in the character of the surface was noted.

Results

The schedule of experiments reported here is summarized by Table I. Figs. 1 through 6 show the time to least perceptible discoloration for various conditions of illumination and temperature. Figs. 7 and 8 are spectral distribution curves showing the filter characteristics of two of the filters.

It is apparent from an inspection of the curves (Figs. 1 through 6) that the discoloration is a function of time, temperature, light level, and spectral quality of the illumination. For example, conditions of high temperature and high illumination promote rapid discoloration for both tungsten and fluorescent lamp sources. The least perceptible discoloration occurs in good agreement with previous investigations for other materials as a direct

function of "footcandle-hours," (ft-c-hr) when considering only one type of unfiltered light source and especially so at the normal 40F operating temperature.

The same correlation does not exist, however, when considering sensibly equal illumination of different spectral quality. Thus, at 40F, an exposure of 93 fc-hr with a fluorescent source is required to produce least perceptible discoloration (Fig. 2) whereas approximately 159 fc-hr are required for tungsten sources (Fig. 1). The discrepancy becomes even greater at lower temperatures. Thus, at 35F, the fluorescent source requires 135 fc-hr (Fig. 2) and the tungsten source requires 300 fc-hr (Fig. 1). These differences suggested that the yellow and red predominance of tungsten sources was advantageous when considering the display lighting of meat for more reason than appearance alone. To test the validity of this line of thought, the fluorescent source was equipped with a Noviol "C" 2.05 mm filter that cut off all wavelengths shorter than approximately 4500A. This filter produces a definitely yellow light. It was considered suitable, however, as a means of testing the assumption that the blue and near ultraviolet radiations were mainly responsible for the discoloration. The results of this run are shown in Fig. 3. They reveal a significant increase of time necessary for least perceptible discoloration at 40F.

Two other filter materials (Catavar 1001, Fig. 4 and a commercially available filter, Fig. 5) were tested with significant though mediocre results. In

TABLE II.—Discoloration of Veal Loaf Under Diverse Conditions.

Light source	Filter	Fc.	Ft-c-hr to least perceptible discoloration 40 F	50 F	60 F
Tungsten 100 w.	none	150	159	97	82
"	"	100	212	142	135
"	"	50	165	130	107
20-w.—Fluorescent white	none	150	93	75	75
"	"	100	110	85	67
"	"	50	81	54	44
20-w.—Fluorescent white	Noviol "C"	150	435	381	374
"	"	100	390	340	335
"	"	50	260	212	200
20-w.—Fluorescent white	Catavar 1001	150	172	123	90
"	"	100	142	102	70
"	"	50	85	71	40
20-w.—Fluorescent white	A	150	168	120	90
"	A commercially	100	153	100	72
"	available	50	100	67	43
	filter				
20-w.—Fluorescent white	Tenite I	150	150	105	82
"	Amber acetate	100	160	90	65
	Color 7695	50	125	65	41
Daylight, outdoor exposure on a cloudy day	none	1100	Temperature of sample 65 F		58

Note: To obtain time for least perceptible discoloration divide "ft-c-hr" by "fc."

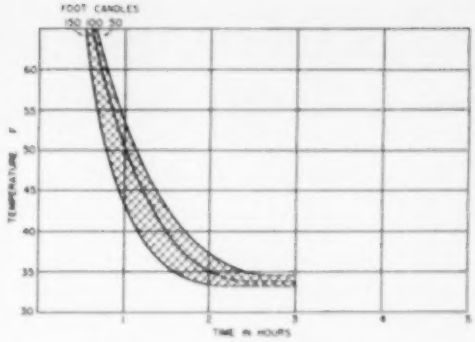

Figure 4. Time for least perceptible discoloration in veal loaf. Light source—20-watt white fluorescent with Catavar 1001 filter.

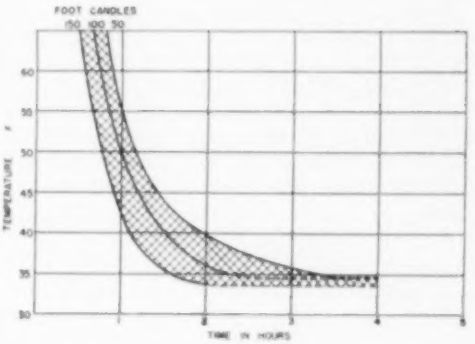

Figure 5. Time for least perceptible discoloration in veal loaf. Light source—fluorescent, 20-watt white with commercial filter sold for the purpose.

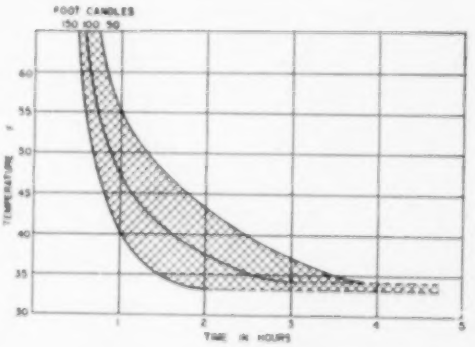

Figure 6. Time for least perceptible discoloration in veal loaf. Light source—20-watt white fluorescent. Filter—Tenite "I" color 7695 amber acetate.

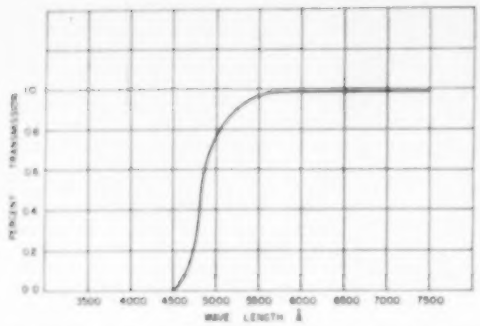

Figure 7. Spectral absorption of Noviol "C" 2.05 mm filter.

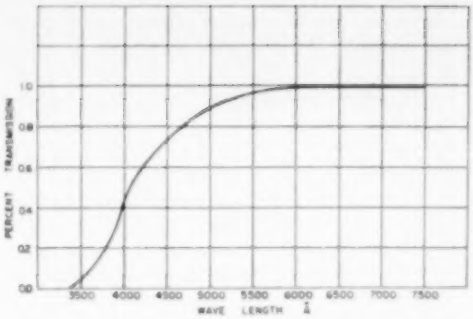

Figure 8. Spectral absorption of Tenite "I" amber acetate color 7695.

each case, a decrease in radiations in the neighborhood of 4000A, resulted in a significant increase in the length of time necessary to produce discoloration at the normal 40F operating temperature.

A third filter using "Tenite I" amber acetate Color 7695 resulted in an increase of time to least perceptible discoloration that was somewhat greater than for the first two filters tested. See Fig. 6.

A condensation of the information presented in the various figures is presented in Table II.

Conclusions

For prepared meats wrapped in cellophane and exposed to illumination levels between 50 and 150 footcandles, the time required to produce "least perceptible discoloration" is a function of time, temperature, quantity of illumination, and the spectral quality of the light. Preliminary investigations indicate that the shorter wavelengths of visible light are more effective in producing discoloration than the longer visible wavelengths.

Filters selected for their ability to absorb wavelengths in the 4000A range and interposed between the fluorescent source and the meat produced a significant increase in the time required for least perceptible discoloration.

Plastic Photometer

A 700-pound 9-foot plastic photometer to be used to measure the light output of eight-foot slimline fluorescent lamps was recently put into service at the Westinghouse Lamp Division, Bloomfield, N. J.

Fluorescent lamps to be tested are first warmed to normal operating temperature in a rack adjacent to the photometer. They are then fed mechanically into the sphere to eliminate the possibility of damaging the interior reflecting surface. A light-sensitive photocell in the sphere measures the light output of the lamp; the value is read on an instrument at the operator's table, together with values of wattage, voltage, and current. Carefully controlled laboratory temperature and humidity make possible light-measuring accuracies of more than 99 per cent.

Eleven coats of interior paint, including six top coats of a special chalk-white paint that rubs off if touched, provide ideal reflection conditions. Every three months, the sphere interior must be repainted with five coats of this paint.

Studies of the Visual and Lighting Problems of Television in the Home

By E. W. COMMERY

EXPERIMENTS IN the late "nineties" confirmed the view that cathode rays are moving, negatively charged particles, and that in a vacuum, with a cathode and properly arranged anodes, these rays could be made to move at a uniform velocity after several steps of acceleration. They could also be deflected inside a vacuum tube in any direction by either electrostatic or magnetic fields. At the point of impact these rays even caused the glass enclosure to glow. These early tubes played an extremely important part in the development of the electrical theory of matter. With them the classical experiments to determine the ratio of the electron charge to its mass were made.

In the early part of 1930 prototypes of our present cathode-ray television picture-tubes were still laboratory devices. Their cost was extremely high and their life expectancy was around thirty hours. Since then has come an amazing succession of events in which the present type of cathode-ray picture-tube has played the lead role in bringing television right into the American home. Its impact on our family life is not completely foreseeable, however, thousands and even millions of families are experiencing the terrific dominance of television in their homes today. Its force changes almost every family routine for many weeks after a new set is installed. It constantly bids for attention, and it is hard to believe it will not become a significant part of family life.

The Influence of Theatre and Motion Pictures

Now each evening as darkness comes on, all lighting habits of the past are swept aside and the family attends the theatre at home. The spirit of attending a show may be hardly sensed, but underneath it all the television program is like the theatre, and by the appearance of the picture itself, black and white and in motion, it strongly suggests the motion picture. This latter mental association "demands" a dark house at night even though the same television receiver was viewed over long periods in the same room in the earlier daylight hours. The play and the stage also suggest a dark house since it has long been customary to dim the lights as the curtain goes up. The reasons for using this mental conditioning are rather well known in theatre art.

Visual discomfort in viewing motion pictures is avoided through large picture size and low screen brightness even though the house lighting is carried at low levels.

In the theatre the size of the stage, its depth, its normal brightness level, which averages substantially above the motion-picture screen, and its freedom from excessive brightness-ratios, except for brief intervals, as well as the effect of the light from the stage reflected into the house, all combine to provide visual comfort for the audience.

Influences from both the stage and motion-picture theatre cannot be denied. In this study a critical examination of both was made. In the case of the motion-picture theatre, a significant scale-of-brightness measurements and a suggested set of visual interpretations are presented since they afford the basic reasons for viewing motion pictures in a darkened theatre. Similar measurements on typical well-designed television receivers are presented. Comparisons of the two clarify the question, shall television be viewed in the dark, in a dimly lighted room, or a normally lighted room?

The most frequently encountered questions pertaining to the production of the television picture, its viewing, and the lighting of rooms for viewing the picture are taken up in the order just stated. Throughout the following discussion the points offered, discussed, or disposed of are based upon operating well-designed receivers at the best obtainable high-brightness picture-point on a good telecast picture signal. To attempt to include discussions of departures from a "best picture," that is, from strong and weak signals or an improperly adjusted receiver or antenna would lead into an almost endless number of exceptions that could scarcely ever be duplicated at any one time. The

A paper presented at the National Technical Conference of the Illuminating Engineering Society held September 20-23, 1949, French Lick, Indiana. Author: General Electric Co., Nela Park, Cleveland, Ohio.

discussion is not intended to present methods of diagnosing the causes for unsatisfactory pictures, instead it is intended to aid in particular the lighting specialist, the television-receiver designer, the designer of furniture, and the interior designer in bringing present television to the home with the highest attainable visual comfort. While the discussion presented here cannot possibly close this subject, the whole art and science of television is in its infancy, it is hoped that it will offer much to clear up the apparent confusion that abounds today on some of the problems discussed.

Television Picture Formation

The generation and forming of the picture is of particular interest to lighting specialists since the cathode-ray picture-tube used is a light-source. The inside face of the tube is phosphor coated as is the regular lighting-service fluorescent lamp. In the former a tiny stream of electrons is generated, directed, and brought to a minute focus on this phosphor coating, which causes it to glow at one point. In the latter, energy at 2537 Angstrom units strikes the phosphor causing it to fluoresce all over. Parts of a typical picture-tube are shown in Fig. 1. Applying the proper voltages to the various parts of the tube causes a tiny spot of light to appear at the one point shown. Changing the bias voltage between the control grid and the adjacent anode increases or decreases the quantity of electrons in the beam, which in turn increases and decreases the brightness of this spot of light. If the control grid is made sufficiently negative with respect to the anodes, the flow of electrons can be stopped. Under this condition the spot of light would be extinguished. As the bias is less negative, the spot becomes brighter. The brightness of this spot can increase and decrease with bias voltage changes with extreme rapidity. If some means can be supplied to swing the electron beam across the face of the tube with sufficient speed and often enough, persistence of vision will make it appear as a continuous line of light. To make the whole tube luminous, either magnetic or electrostatic fields are applied to the electron beam which drive it back and forth horizontally and at the same time pull it up and down at the right frequency to have all parts of the tube covered evenly at one value of the control grid bias voltage. When all of this is done, properly coordinated, and at sufficient speed to avoid flicker, we have an evenly glowing electron-beam fluorescent light-source. Without a television picture signal, we therefore see an evenly illuminated picture-tube. The exact path of travel of the electron beam is schematically illustrated in Fig. 2. Beginning at the top left corner, the first active luminous line snaps to the right. At this point it is blanked out and retraces to the left edge along the path of the white broken line. Now the beam spot is down one step and it again snaps to the right. As in the case of the end of the first active line or trace, the beam returns to the left blanked out, this time across the second white broken line. This is repeated until $262\frac{1}{2}$ lines have been traced and made luminous. Having arrived at the bottom, the beam blanks out to return to the top of the

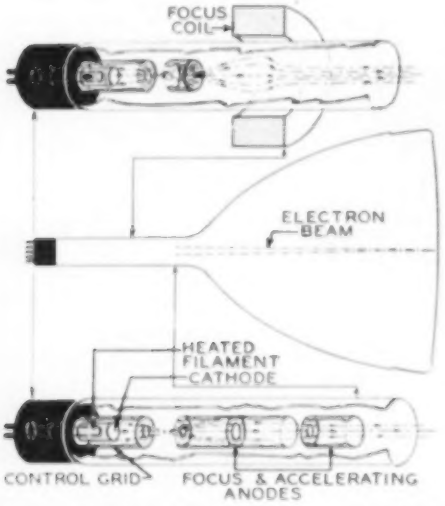

Figure 1. The cathode-ray television picture-tube with its focused electron beam generates traces of varying light across its phosphor-coated face to reproduce scene and action. Focusing the electron beam magnetically is shown above and electrostatically below.

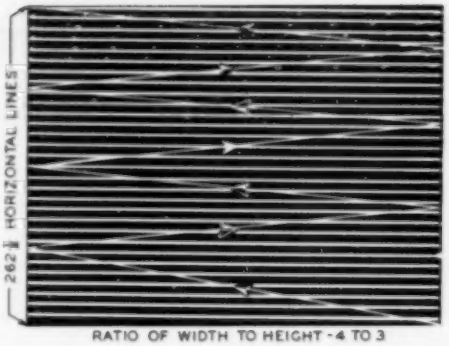

Figure 2. The electron beam traces the picture from left to right starting at the top. Its return at the end of each line is dark. The frame requires $262\frac{1}{2}$ traces. Two of these frames immediately following each other, interlaced, form a complete picture, thirty per second.

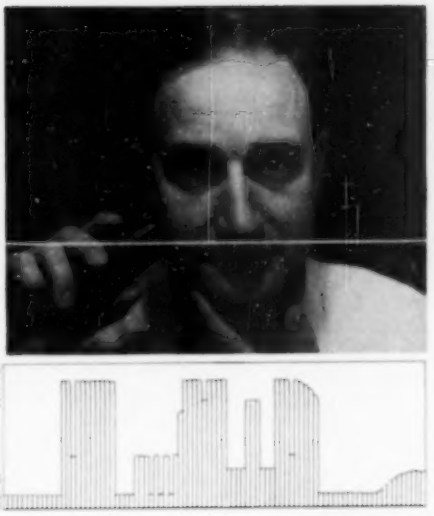

Figure 3. Varying the strength of the electron beam delineates the tones of each trace across the picture. The diagram below the picture suggests the changes in the electron beam and the corresponding tone values from black to white along one trace located by the white line on the picture.

frame. The path of the return is suggested by the thin white line which starts at the lower-right corner and follows to the left and right as indicated by the black and white arrows. The complete trace from top to bottom and return occupies one-sixtieth of a second. Immediately this whole trace is repeated in *between* the lines made the first time to complete one filled, interlaced, overall pattern in one-thirtieth of a second. The two complete traces comprise the 525 horizontal lines that create one picture frame. Complete frames of light or pictures are presented at the rate of 30 per second, a rate well above the flicker value.

To complete the description of picture portrayal, we need to examine the changes in the brightness of the spot made by the electron beam when it creates a single line of a given picture. In Fig. 3 the changes in spot brightness shown in the graph below the picture are indicative of a single trace required to create one line of the picture.

Picture Size

One of the first questions that arises in the mind of an owner or potential owner must be, how big is the picture? Manufacturers have presented television sets more often in terms of the picture size than by tube diameter. There is no standard practice as to how much of the tube is really unmasked for viewing. Mask shapes and picture areas for given tube sizes have varied considerably. They now appear to be going toward a recently developed expanded shape which affords a greater picture area than found six months ago. In the fall of 1948 a summary of forty-nine receivers using ten-inch tubes revealed that the picture areas ranged from 51.5 to 55 square inches with over half at 52. Mask A in Fig. 4, the central dotted area, limited by the black broken line, represents the shape of a 51-square-inch picture. By expanding through the white area immediately surrounding Mask A, we obtain the present popular expanded picture, Mask B, which affords picture areas up to approximately 61 square inches. The expanded picture mask increases the picture height only slightly and the enlargement of the portrayal of the subject is increased a small amount. Mask B may provide a more pleasing effect or appearance. Visually, one does not get a substantially better reproduction of the television signal from B, although the round ends may feel softer than the straight vertical sides of A. Mask shape changes are a part of the evolution of the art in television.

The ratio of the picture width to height in both television (as transmitted) and motion pictures is standard at 4/3. This is the "aspect ratio" of each. Mask A in Fig. 4 adheres very closely to this ratio. Its corners are filleted rather strongly to allow for expanding the picture size. Mask B may change this ratio but not to such an extent that significant distortion is introduced. More of the corners are lost. Finally, the picture can be pushed out through the dark white-dotted area marked C to fill a circle.

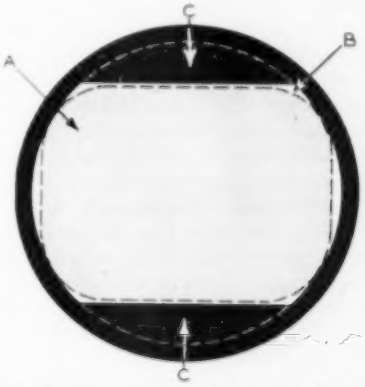

Figure 4. Illustrating three masks for the picture tube. Mask A has an aspect ratio of 4/3. "A" extended through the white surround becomes "B," the present popular expanded picture. A blow-up of the center of "A" or "B" is possible by filling the remaining area "C" to make a circle.

This can be done two ways through adjustments of the horizontal and vertical scanning circuits of the receiver. One is to over-scan the picture vertically with the horizontal scanning adjusted to fill the circle at the left and right edges. Done this way, people in the picture are thin and tall just as they are when viewed in comparably designed concave mirrors placed vertically. Instead of a normal aspect ratio of 4/3, it is nearer 1/1. The other way is to over-scan both horizontally and vertically to fill the circle and still retain the 4/3 ratio. The top and bottom of the picture may coincide with the upper and lower edges of the circular mask, but the vertical sides of the picture go out and beyond the circle. Now a substantial part of the picture is lost, approximately 40 per cent. With this latter method, the picture can be free from distortion. Since the scanning oscillators can be adjusted to expand the picture and still avoid distortion, receivers which afford both the regular pattern, such as A or B and an expanded blow-up of the center of the picture such as C, are now being offered. Careful observations of the resolution or focus of the circular blow-up picture have not been made, especially those blown up from the center of distant scenes. If the distant scene does not have good detail in it, a blow-up of it will not always improve the quality of the picture.

The question of greater importance regarding picture size is one of the size of the tube itself. Direct-view picture tubes now range in diameter from 3 to 20 inches. Until recently the 10-inch has been the most popular tube size. If the price per square inch of picture can be taken as an important factor, we may expect to see a somewhat larger picture-tube come into favor. Early in the year a summary of a large number of receivers — all 10-inch tube table models — showed the average price per square inch of picture to be $5.50. Approximately six months later new designs of 10-inch table models range from $3.90 to $4.50 per square inch of picture. The newest large tube sets are now being introduced at "picture-square-inch" prices significantly lower than these. It appears that the trend to receivers with 10-inch tubes and larger is being established. Reliable methods of appraising the relative sustained visual values of the pictures from various tube sizes have not been found. There is every reason to observe, the larger the picture the better, due to all the relationships that exist between size, contrast, and brightness. There is also a certain indefinable something associated with life-size pictures, even though we have no trouble accepting or visually interpreting close-ups of a baseball player as being life-size on a 10-inch tube.

Viewing Distance

With television, the picture viewed is not in good focus at all times over its entire area. It is "ruled" with a set of horizontal lines which increase in size and spacing with tube size. Electrical disturbances are reproduced as physically larger elements of the tube face with larger pictures. All of these and other factors make it desirable to view the larger and larger tubes farther and farther away. Increasing size does not do away with many of the problems. This does not mean, however, that the viewer must at all times remove himself from the largest picture to such an extent that he is no better off than if he were viewing a much smaller set at a correspondingly normal distance. There is obvious value in sheer size alone, but it may not be taken as the sole criteria any more than other emphasized factors of performance. For example, the later discussion of reproducing a good scale of tones from black to white reveals how very important tone reproduction may be.

Since tube size and viewing distance are in some ways exactly related, we can be quite specific on this point. The traces shown in Fig. 2 create a set of gray lines across the picture such as is illustrated in Fig. 5. These spacings are directly related to the actual picture height of the frame and the number of horizontal traces. Using Mask B in Fig. 4 on a ten-inch tube, these horizontal lines occur at approximately thirty-six per inch. When viewed at 8 feet, these lines subtend a visual angle of 1.2 minutes. Depending upon the distribution of light in the picture, they are at the borderline of being seen under many conditions. The data of Luckiesh and Moss[1] on the four fundamental factors of vision show that we may expect to just resolve 1.2

Figure 5. A section of picture actual size from a 10-inch tube. Fusion of the horizontal lines and other electrical disturbances in the picture are effected by adequate viewing distance.

minutes when the background brightness ranges from 5 to 100 footlamberts and the contrast between the object and its background is less than 50 per cent. All of these quantitative values exist with this situation. To get fusion, we need a slightly greater distance between the viewer and the tube. One to two feet added to the basic distance of 8 feet are desirable in not only fusing the horizontal trace pattern but also for getting the minute surface disturbances that often occur fused into a state of visual equilibrium. Then, too, this rule of distance supplies a better sense of being in focus for the more distant elements of scenes that are not presented in the best definition or in a good range of tones. Viewing distance may therefore be summarized as ten times the diameter of the picture tube, both in inches, plus one or two feet. For long viewing periods, even greater distances appear to be very desirable. Distances beyond those given are also dependent upon the resolution and steadiness of all parts of the picture. To mask poorer reception and reproduction, move farther away from the receiver. This distance rule cannot be applied to the extremely small tubes since only a general visualization can be obtained from them beyond several feet.

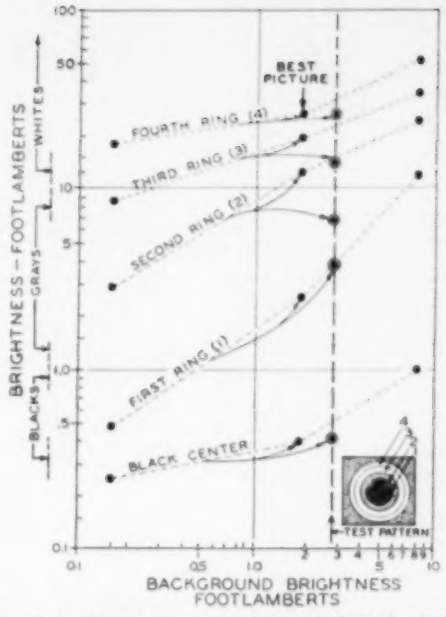

Figure 6. Showing the various interpretations of a test-pattern gray-scale at different settings of the background or brightness control. Maximum practical contrast control settings. Type 10BP4 picture tube.

Evaluating Picture Tone-Range

While there are many important ways of evaluating the performance of television receivers, most of them contribute to the sensitivity, selectivity, stability and the reliability of the receiver. After all of these have been assured, we should examine the ability of the receiver to interpret the complete picture signal. In this study a considerable amount of work was devoted to this end since it is finally the end product of the whole chain of events involved. At this point in the art of receiver design and telecasting, remarkably high quality reproductions of the original scenes can be obtained. That they are not always obtained on everyone's receiver is obvious. The method of picture quality appraisal proposed here is intended to provide a means of evaluating the tone-range interpretation of the receiver. Through proper settings of the contrast and brightness controls of the receiver, we can always produce black and white. In fact, these two sensations are obtained over a wide range of the brightness control alone. The real question includes not only the relative and absolute brightness values of black and white but how well does the receiver reproduce the scale as telecast in between these limits. In attempting to answer this question, we should begin by turning to the test pattern sent out by the station. These are of different design in different parts of the country; however, they usually incorporate some form of "gray scale." In the lower corner of Fig. 6 is shown an elementary test pattern with a gray background enclosing a black disk surrounded by 4 circles going through three grays to white. Their absolute brightness-values are plotted along the vertical dashed line at a background brightness of 2.7 footlamberts. Reproduced on the television receiver at this background brightness, ideally they would have the same set of brightness values. This exact reproduction may not be attainable for numbers of reasons outside the scope of this discussion. For example, if the maximum high-light brightness achievable on the receiver is substantially below the upper white value, the whole scale is compressed, although the uniform increment of the upper part of the scale might be obtained.

The principal ideas to be gained from this part of the study are contained in Fig. 6. While the receiver may not reproduce the proper intervals in the gray scale, there is a "best picture" setting of the brightness control with the maximum workable contrast setting. Changes of the absolute brightness values of each one of the steps of the test pattern with changes of the brightness control are shown in this figure. Various positions of the brightness

control produce changes of the background. These brightnesses are scaled along the abscissa, while the ordinate scale applies to the test pattern element brightness. Ring (1) and the test background are always at the same brightness-level.

Turning the brightness control from the low point on the left to the extreme high on the right produces a variety of changes in the interpretation of the signal values as set at 2.7 footlambert background brightness. Actually, at the low point both the center and ring (1) are black. In other words, there are no deep grays. The second ring also moves down proportionately more than it should, while rings 3 and 4 remain in the correct relative positions. This picture is completely unsatisfactory since it will force out the middle tones. By referring to Fig. 7, it is found that it is too near the right-hand end of the scale. The viewer is often tempted to use a setting of low brightness in an effort to improve washed-out, low-contrast telecasts. As the brightness control is increased to the extreme right (Fig. 6), we pass the nearest approach to the best picture interpretation on to a maximum brightness exactly twice that of the best picture setting. This high value "lifts" the scene —especially if it is outdoors, but it disappoints since it decreases the relative sensation spacing at the upper end very markedly. Note how much closer the first ring is to rings 2, 3, and 4. This shift adds greatly to the original difficulty of having rings 4, 3, and 2 closer together than they should be. Too much of the picture is rendered in small differences at the white end of the scale and the blacks and heavy grays are too high in absolute value. From the author's own observation, definite settings of both the brightness and contrast controls should be made when viewing a given television station test pattern. These control positions can be marked and always used when receiving programs from this station. Adjusting the picture setting when viewing the gray scale of the test pattern can be done with greater reliability than making these adjustments from any one program. Resetting them frequently does not produce any significant improvement. The extended usefulness of Fig. 6 will be especially noted when examining the question of filters at this point.

Viewing Filters

An absorbing colorless filter placed in front of a picure-tube would be properly considered when the T.V. signal, antenna, and receiver produce good picture quality with high average brightness if there is (a) direct-view glare discomfort, or (b) undue "wash" of the dark end of the picture scale.

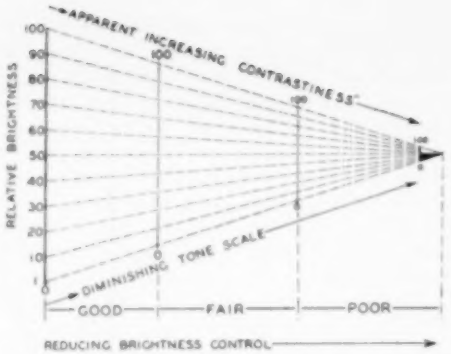

Figure 7. Schematic portrayal of the crowding of the gray-scale when the brightness control is reduced from the "best picture" position to its lowest position.

In the first situation the glare sensation is induced by the lack of sufficient light on areas forming the visual field around the picture. In the second, the "wash" is induced by too much light striking the picture-tube directly. This latter situation would be encountered much more frequently and to a greater degree in the daytime than at night.

Where the surrounding illumination is low and the picture uncomfortably bright, the addition of the filter reduces the overall brightness of the picture, which in turn affords relief. One of the significant visual effects associated with filters is that the blacks and dark grays are somewhat darker or blacker. Any filter of reasonable transmission does not change the distribution of the sensation values over the picture, although the absolute brightnesses are lowered. Commercially, filter transmissions are commonly as low as thirty per cent.

By reducing the five test pattern values in Fig. 6 to the values that would result with any selected filter transmission, it will be noted that the spacings between each of the values remain the same.

Some program productions might go to considerable pains to work in a low key to create suspense, mystery, vagueness, etc. When this is the case, a good range of deep tones from the picture-tube needs to be guarded from too much incident light. The "introduction" of an appropriate filter for such programs would provide this scale a better opportunity to work. At the same time it would not be necessary to sit in a dark room. However, tone range at the low end of the scale must be in the picture itself. The filter cannot introduce sensation steps that are not in the original.

The effect of greater contrast may often result when the program does not employ values in the middle of the tone range. This, of course, brings

white and black together and each enhances the other.

Other programs such as outdoor sports or events in well-lighted arenas, newscasts, and studio sets, etc., with average lighting, have more life and snap in them when portrayed at high average brightness level. Here real blacks are not too important. The reduced brightness associated with many filters is not compatible with these desired high-level visual effects. Proper arrangement of lighting and placement of the receiver for both day and night viewing can nearly always provide satisfactory visual conditions for viewing well-lighted and outdoor scenes without the use of filters.

At this point we might examine the question of getting a less bright picture and blacker blacks by merely reducing the setting of the brightness control of the receiver. For example, by lowering the background brightness of the picture fifty per cent instead of using a 50 per cent filter. Fig. 6 is useful for analyzing the question and making the comparison.

Brightness Values of Test Pattern Elements (Footlamberts)

Test Pattern Element	Typical Reception	Brightness Control at 50%	Filter (50%) on Typical Reception
4	28	35	14
3	20	16	10
2	12	8.3	6
1	2.8	1.4	1.4
Black	0.4	0.35	0.2

Again it is noted, the filter does not change the original increment ratios between the steps from white to black. When the brightness control is lowered to bring ring 2 and the background down to 1.4 footlamberts so as to match the brightness of these same elements viewed through the filter, that is the only condition of match in each case. The white end of the scale reduced by the brightness control has only been lowered a small amount, the black end only slightly, while the dark gray values coincide. From the slopes of the lines representing elements 4, 3, 2, and black, it is evident that lowering and raising the brightness control changes the relationships inside the tone scale, while a simple filter does not, hence there is no setting of the brightness control that will match the quality of the "best picture" setting. Lowering the brightness control does not provide a picture comparable with that obtained with a filter on the "best picture" setting.

With the brightest types of tubes which would yield a "best picture" at high levels, the range in absolute brightness values between black and white reproduced increases. This greater range permits more incident light on the picture than when the receiver and tube together are unable to produce a good range of absolute value, black to white. In fact, if the receiver operating at its "best" produces pictures at too low a level of absolute values, a darkened room may be the best for viewing since it can stand so little stray light and suffers too much brightness reduction when filtered. When contemplating the use of a filter, it is well to know or measure its direct transmission. This value may be used to estimate the reduction of the viewed picture brightness, while the square of this value may be used to determine the reduction of incident light striking the tube, which in turn produces the brightness values that must be added to all parts of the picture. The reflectance of the tube face is approximately 50 per cent. If tube brightnesses could be increased several fold at no marked increase in receiver and tube cost, filters could be added to permit greater freedom of placing the receiver in rooms, both day and night, with respect to the amount of light that could be permitted to fall on the tube face.

Viewing Lenses

Viewing lenses of heroic dimensions, sufficient to even include the 16-inch tube, provide an enlarged image of the picture. These are usually well-designed, clear plastic containers filled with a mineral oil. The thickness of this oil layer may suggest considerable loss of picture brightness due to absorption. Measurements show only a small reduction in picture brightness. The gathering power of the lens appears to be sufficient to offset the loss of light through the materials of the lens. The position of the viewer is reasonably critical to avoid distortion. Where the number of viewers is limited and the tube size is small, lenses offer advantages.

Surroundings for Viewing Motion and Television Pictures

The assumption that the viewers' surroundings should be dark was discussed at the beginning. In addition to the mental attitude of "going to the show," many people feel they can see more by viewing the picture in the dark, and finally, there are no visible distractions in the dark. This is the point at which erroneous conclusions have usually been drawn. Television pictures and motion pictures, as viewed on their respective screens, are quite different in at least two ways. Each of these should be examined critically. Beginning with the motion picture, we may properly ask why they are viewed in near-dark rooms, since that is the normal practice? Measurements of the brightness of all parts of the screen when viewing a high quality black and white motion picture reveals some sur-

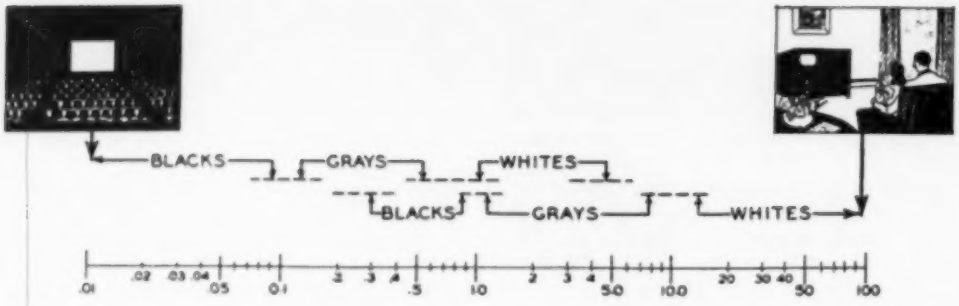

Figure 8. Comparisons of the ranges in brightness seen and the sensations created on the motion-picture screen and the television picture-tube show how markedly they differ. (Values in footlamberts.)

prising values to those not familiar with this art. For example, a white pillow case hung out in full sunshine is produced at 5 footlamberts. The sensation of bright window curtains, struck with sunlight and viewed from indoors, may be produced in the range from 5 to 7 footlamberts. A beautiful scale of grays are provided from a few tenths footlambert up to 1, and a scale of deep grays and blacks are presented at less than 0.1 footlambert and down to 0.01 footlambert. The best modern projection practice might double these values. The thing to consider here is that the values just given are commonly used and they do provide the desired sensation scale. The dark house and the low brightness screen lowers the viewers' adaptation so much that they have no difficulty in seeing through the great range of the black end of the scale. The blackest value with television begins around 0.2 to 0.3 footlambert, over ten times the working black range of motion pictures. In the motion picture theatre we have to hold low adaptation, aside from the need for eliminating stray light to prevent "wash" of the blacks and grays; that is, if we are going to use night scenes beautifully scaled in extremely low brightness tones. We carefully sensitize the eyes to make all these visual interpretations possible through the use of a dark house and moderate screen brightness. If motion pictures were projected at ten or more times the present brightness range, we would be reasonably close to the operation of a good television receiver, particularly when the brightness values that are obtainable with the newest picture tubes having aluminized screens are considered.

In an attempt to diagram the marked differences in the positions of these two sensation scales, the diagram of Fig. 8 has been developed. M.P. presents approximately the black-to-white scales for the motion picture, while T.V. presents the television scale. We have not viewed a full-sized, full-length motion picture projected at ten times the present normal value in a darkened house. It hardly seems possible that it would not produce visual discomfort.

With white values running from 15 to 50 footlamberts and up with television, we do not need to drop adaptation way down to get high sensitivity. These values look white in normal surroundings. The black end of the scale is also relatively high, so there is no need for sensitivity to view a scale of black values that never exist in television.

The usual discomfort producing qualities of television pictures may also be visualized still another and more direct way and that is to view the picture for a period of five to ten minutes in an unlighted interior. Follow this by gradually increasing the background brightness against which the picture is viewed. This is easily done with a 60-watt lamp placed back of the receiver and moved away from the wall a foot or more so as to expand the background lighting pattern. With a variable resistance in the lamp circuit, the background brightness can be brought up to the average background brightness of the tube or higher. With the bright parts of the background brought up to the background brightness of the tube, the comfort and general viewing sensations are reasonably satisfactory. Increasing the background above this point introduces discomfort since the pattern of light is not large enough. It needs help from added overall room lighting. That nothing is lost in the television picture under these lighting conditions is simply illustrated by switching the back lighting off or down in steps to off. Switching to off, of course, produces an annoying visual shock.

The exact value of the brightness of the back-

Figure 9. The narrow framing of the case and the added back lighting combine to provide some of the basic means for greater visual comfort. A lighter finished cabinet would also aid the visual condition.

ground against which the picture is viewed does not appear to be critical until the point of discomfort-comfort is reached due to the localized distribution of light. When viewed against large, extensive areas of brightness, some of the better known ratios of lighting practice can be considered. Now we get into the realm of attempting to decide between the psychological effect we like as much as that of the visual comfort to be attained over long viewing periods. At this time and until techniques can be devised for evaluating or relating eyestrain for long, sustained periods of viewing to other known factors, average surround brightnesses back of the picture of not less than one tenth the background tube brightness appear to be a reasonable compromise between the important measurable and unmeasurable variables.

Many people have felt some form of eyestrain or eye muscular fatigue when viewing television programs for entire evenings. Many have lessened these effects by moving farther away, by adding filters, by returning to some form of room illumination, and by turning the eyes away from the picture a few minutes periodically, etc. Relief of one kind or another has been afforded.

Earlier the picture size and viewing distances were discussed. Further careful examination of the optical geometry involved between the viewer and the picture indicates an important reason for visual difficulty. The picture on a 10-inch tube viewed at 8 feet subtends an angle of about 5 degrees at the eye. This is not much larger visually than a three-cent postage stamp held 14 inches from the eye. If we only consider the geometry of the situation, we are fixing on a small area for all the visual information. A stamp mounted on a gray card held 14 inches from the eye and viewed for 30 minutes will emphasize the fact that visually the television screen is something new in our visual experiences. Parallels of this eye use may be found in industry. The mariner, and more recently, the air plane pilot must often use their eyes similarly, although under different surround conditions. At

Figure 10. Modern wall-to-wall cornice lighting also supplies background lighting, which still leaves a good margin of emphasis for the picture.

Figure 11. Highly shielded down lights in conjunction with back lighting at the receiver provides an interesting environment for viewing the program.

least this close visual attention to such a small visual field is not paralleled in the home. Relief from this visual "aiming" for long periods appears to be very desirable. The lighted background makes it easy for the eye to get away from the picture. In addition, periodic rest periods should be considered. Studies covering the intervals and duration of rest periods have not been made.

Lighting Principles

The basic principle of creating good visual conditions with lighting are illustrated in Figs. 9 to 12. Various ways of creating background brightness with a minimum of light striking the tube face will occur to the lighting designer. These are but a few. In addition, the drawn wall curtain of light material can be lighted from behind. Alcoved areas with properly built-in lighting will also serve.

In the simplest forms of lighting application, proper arrangement of the floor and table lamps can be employed as well as the indirect lighting torchere. When these are to be used, they should have extremely low shade brightnesses. Most of the present glass bowls on the floor torcheres have brightnesses may times higher than they should be. Average picture-tube brightnesses range between 10 and 20 footlamberts. Objects or areas in the room that are included in the visual field of the viewer, at or above this general brightness range, afford distractions that may not be acceptable.

In conclusion, the author wishes to make one additional and strictly personal observation. When the work on this subject commenced about one year ago, every means for preserving the picture in a darkened room was sought. As the months have gone by and more and more people closely associated with the presentation of television have been contacted, it has become more and more ob-

Figure 12. Portable lamps that are included in the field of view should have opaque or very low brightness shades. Equipped with two-filament bulbs, the medium or low filament would be used. The inside lower edge of the shade is darkened.

vious that it is natural for most people to start that way. With many hours of viewing involved in the preparation of this material, it becomes very clear that the desire for a dark room and the complete shunning of light here and there must be largely a mental attitude. When this mental attitude is adequately conditioned by repeated viewing of television programs in properly lighted surroundings, the dark room becomes a condition that is avoided more often than it is sought. It will undoubtedly take an intelligent program over some years to bring this one basic idea into the understanding of the American family.

Reference

1. Luckiesh, Matthew, and Moss, Frank K., *The Science of Seeing*, D. Van Nostrand Co., New York, 1937, p. 129.

DISCUSSION

M. N. Waterman*: Preliminary results of tests conducted in a home in New Jersey suggest that if the author had had more time and space his paper might well have placed more emphasis on the effect of brightness (or lack of it) of the face of the set surrounding the viewing screen on the comfort of viewing. By reference to Figure 9 of the paper one will see that the visual field of the viewer consists of the picture tube surrounded by a frame afforded by the cabinet plus the background area beyond the cabinet, consisting usually of the walls, ceiling, and floor or table top. Therefore, the eye has to adjust itself to the variations in brightness between these areas.

Although we are told that ideal seeing conditions call for 1 to 1 brightness ratios in the field of view, I am sure that most of us would feel that it was undesirable to have no frame at all around our picture and to have the picture merely fade out into an area of equal brightness. Some frame seems more desirable aesthetically. However, it is obvious that too dark a frame may give discomfort. In our tests, for example, we found that the viewing of one table model with a dark mahogany case was made significantly more comfortable by placing a mask of brown packing cardboard over the dark mahogany. We also found a set with a blond wood case more comfortable to view than the mahogany set under the same room conditions.

For the face of the set to have any brightness at all, some light must of course fall on it. Such light inevitably falls on the tube also and reduces the sharpness of the "blacks." However, if this is not carried too far, I believe the improvement in comfort will more than offset the disadvantage of slight reduction in picture contrasts.

Our tests indicate that the 1 to 10 ratio between background and tube brightness suggested by the author is probably of the right order although not critical.

In conclusion, I think that we are indebted to Mr. Commery for sound lighting suggestions in addition to valuable background information on the nature of the television picture.

Mary Taepke**: The fundamentals of television reproduction are certainly of interest to the home lighting advisor and home lighting specialists in particular. Any information on the "behind the scenes" workings of the actual physical make-up and operation of the cold cathode ray picture tube is valuable as added background knowledge which can be helpful in the discussion of television viewing problems in the home. Of special interest to those giving advice in the field of home lighting would be Mr. Commery's discussion of color filters (when and how to use) mask sizes and tube sizes, viewing distances and variance of tube brightnesses. Speaking strictly from my rather limited experience in this new lighting problem of television lighting—these facts would, and I am sure, will be of most help to me and others in the field.

The home lighting specialist and home lighting advisor is faced with the problem of giving advice to the customer after the set has been installed in the home. Questions or problems on the use of recessed or hidden lighting sources, lighting from cornices to wash backgrounds, the proper use of on the premise lamps and fixtures, etc. are to be faced. Would it not be effective and would we not be doing a better job if we could do some pre-buying education and instruction on the proper type of lighting for the room where the set is to be used?

Some television manufacturers or dealers are already giving limited information on room-wide lighting. I think they should be informed of the importance of light as an important feature in the final satisfaction of the use of the set.

This educational work with manufacturers and dealers seems to be one step in the right direction and any other suggestions from Mr. Commery would be most helpful in effecting better viewing habits for families using television sets.

*Westinghouse Electric Corp., Bloomfield, N. J.

**Home Service Div., Detroit Edison Co.

Reprints of papers published in Illuminating Engineering are available approximately six weeks after receipt of issue.

Esserman's Sets Shining Example

"IN THE HEART of Rome since 1896," is the slogan of Esserman's, a large specialty shop located in Rome, Georgia. The shop is indeed in the center of town, and more than half a century of popularity is proof of good will.

In addition to its other laurels, Esserman's can now stake a claim as one of Georgia's most beautiful stores. A recently completed program of remodeling has boosted the shop to this challenging position.

Esserman's planned carefully for the pleasure and convenience of its customers. The color combinations of the interior are smart and eye-pleasing examples of harmony and contrasts. Displays of merchandise stop and charm the shopper. There is the ideal climate of air conditioning. A public address system, with speakers blended into the decorations, brings soft music and an occasional announcement. A spiral stairway leads leisurely to attractive departments on the second floor, or an automatic elevator will carry you there.

The lighting was planned by lighting engineers of the Georgia Power Company in cooperation with the architects, Poundstone, Godwin and Ayers. Shielded and louvered fluorescent fixtures furnish general illumination of about 50 footcandles, and spotlights are used lavishly to emphasize and enhance many displays.

To quote one authority, "Esserman's lighting system, combining utility with splendor, is serving as a model for store designers."

Data for this installation was furnished by the F. W. Wakefield Brass Co., Vermilion, Ohio.

Daylight in Classrooms

By R. L. BIESELE, JR.

Since daylight is the primary light source in most classrooms, it is essential that the designer know the techniques available for its use in producing a beneficial visual environment. This paper describes an extensive study of the factors affecting the brightness patterns and visual environments in daylighted classrooms, and presents material taken from the study which will assist in effective design for daylight. It is shown that intelligent application of Illuminating Engineering principles to daylight design of classrooms can produce visual environments which fully meet all of the recommendations of the 1948 American Standard Practice for School Lighting.

EFFECTIVE use of daylight in school classrooms is the business of any person intelligently concerned with the health and development of the next generation.

Many studies have indicated the intimate relationship which exists between the visual environment in the classroom and the health, the physical and mental development, and the educational progress of the school child. Other studies have indicated the basic requirements of a beneficial visual environment. Considerable progress has been made toward the practical design of such visual environments.

Schools rely chiefly on daylight through windows for classroom lighting. Progress in this field has been largely a trial and error process, although some engineering approaches have been made to the problem in recent years. The author has previously reported on engineering studies at the W. M. White School, Mexia, Texas,[1] the University Park Elementary School, Dallas, Texas,[2, 3] and the Rosedale School, Austin, Texas.[4] Although these earlier tests were conducted on rather narrow lines of attack, encouraging advances were made in the techniques of daylighting. Changes in reflectances of room finishes, use of a desk arrangement differing from the traditional straight rows parallel with the windows, and introduction of the cloth light-diffuser and of light-directing glass block all had a favorable effect on the brightness pattern in the pupil's visual field.

Additional engineering studies have included those of Professor Leland H. Brown in California.[5, 6] His studies reported on experiments with different classroom shapes, and window arrangements, principally as they affected the uniform distribution of daylight illumination within the classrooms. No claim has been made, however, that any of these earlier arrangements in California or Texas has been a final answer to all the problems.

A broader attack on the problems has appeared desirable, and an extensive series of investigations in this field has been undertaken at Southern Methodist University under the author's direction. These studies have been sponsored jointly by the Detroit Steel Products Company and the Libbey-Owens-Ford Glass Company. The author has been ably assisted in the conduct of the program to date by a number of individuals; in particular by Mr. Joel J. Fleck in 1947-48, and in 1948-49 by Mr. J. W. Griffith.

The purpose of the studies has been to determine the factors affecting the brightness patterns and visual environments in classrooms daylighted through windows. This paper presents certain material developed during the studies which will assist the lighting engineer and architect in effective design for daylight in schools.

This discussion will be confined for brevity to arrangements employing windows, various types of glass, shades, blinds, and other materials readily available at the present time. It will also be confined to unilateral lighting arrangements, primarily because unilateral lighting has been normally used in schools, and also because the solution of unilateral lighting problems has presented the greatest design challenge.

Test Building

The tests reported here have been conducted in a building, Fig. 1, especially constructed for the purpose on the roof of the University Steam plant. This location gave as nearly an unob-

A paper presented at the National Technical Conference of the Illuminating Engineering Society held September 20-23, 1949, French Lick, Indiana. Author: Professor and Head, Department of Electrical Engineering, Southern Methodist University, Dallas, Texas.

Figure 1. Daylight test house on roof of steam plant at Southern Methodist University.

structed sky as could be found in any location convenient to the University.

The building is 32 feet square, oriented so the windows face the cardinal compass points. Steel windows cover the full extent of each wall from three and one-half feet to fourteen feet above the floor. The interior is arranged with a suspended ceiling which is adjustable in height, and with movable partitions to permit orientation of the room inside into any position. The particular tests reported here were all made in a 24 by 30-foot room with a 12-foot ceiling.

Fenestration

The window area available for this room represented approximately 34 per cent of the floor area. The lower portions of the windows were provided with ventilating sash, while the upper portions were fixed. Ventilation, incidentally, proved to be at times a considerable problem in the conduct of the tests. It merits special consideration in any practical classroom design.

Tests indicated that windows should extend the full length of the room. Use of mullions or window heads made no improvement in the brightness patterns in the room, and in most cases detracted from it. In all cases a reduction in window area was accompanied by a comparable reduction in average illumination on the desks. Consequently, all tests were made with maximum available window area.

The window sill was placed at 42 inches from the floor, so as to be at or above the eye level of the seated child. Studies of the visual field indicated that lower sill heights would introduce disturbing areas of high brightness in the periphery of the visual field. Other studies indicated that any increase in illumination produced by such a lower sill height would probably be outweighed in importance by the disturbing effect of the areas of brightness introduced by them.

Window Treatments for Non-Sun Exposures

Plain clear glass is considered the basic window treatment for classrooms, and has been so considered in these tests. Fig. 2 shows an inside view of the room with this window treatment. It is reported here under conditions of clear sky without sun, and of overcast sky.

Vertical louvers have been found useful on non-sun exposures in improving the brightness patterns in the field of view. They do so, however, at the expense of some absorption of the effective light. The vertical louvers employed in the tests are shown in Fig. 3. They are quite simply constructed of redwood slats of the type commonly

Figure 2. Interior view of room showing clear glass windows.

Figure 3. Interior view showing vertical louvers.

employed for Venetian blinds, held vertically and with the blades at a right angle to the window by a wooden frame. The blades are spaced so that the angle of complete shielding extends out to 30° with the window. They were left in the natural brown finish of the redwood. The vertical louver is most effective for shielding out sky brightness under conditions of bright overcast or partly cloudy sky without sun. It is reported here under conditions of clear sky without sun for comparison with the clear glass.

Window Treatment for Sun Exposures

Fixed louvers, so adjusted as to give complete shielding of the sky when viewed from below, were used with the clear glass windows as one of the sun exposure treatments reported here. The blades were tilted upward at 45° as shown in Fig. 4, and were painted flat white on both sides. The results obtained with the fixed louvers are quite comparable to those which would be obtained with properly adjusted Venetian blinds, which are the most common type of horizontal louver.

White translucent shades gave exceedingly good diffusion of the sunlight striking them, but could well have been more translucent. An interior view with the shades which were used in combination with clear glass, is included as Fig. 5.

A diffusing "Aklo" heat absorbing glass used for the portion of the window above six feet from the floor has given satisfactory brightness patterns for the pupils when installed in a west elevation, provided that the sun during normal school hours does not get north of a line extended outward perpendicular to the windows and provided also that the pupils are faced north or northeast in the room. The lower portion of the window has been left with clear glass as a ventilating vision strip. In the particular test reported, with sunlight on the windows, the vision strip was shielded with horizontal louvers. Extremely high brightnesses are encountered when looking at this glass in the direction of the sun, however, and it is questionable whether an attempt should be made to employ this glass without additional shielding.

Figure 4. Interior view showing horizontal louvers.

Figure 5. Interior view showing white cloth shades.

A rolled prismatic glass of a commercial type which has been manufactured for many years is suitable for a non-sun exposure, or for a sun exposure if provided with adequate shielding such as that afforded by the horizontal louvers. In tests on a sun exposure with horizontal louvers, it gave somewhat higher relative utilization than was obtained with clear glass and louvers.

Decoration

There must be a careful balance of reflection factors in the decoration scheme as indicated by the early phases of the investigation. Such balance can be obtained by the use of a single reflectance for the ceiling, one for the entire wall area, and one for the floor. It was desirable, with all the different types of fenestration being investigated, to avoid excessive wall brightness near the windows as compared with task brightness. It was also necessary to avoid excessive brightness ratios between the visual task and the darker areas in the room, and between the windows and adjacent wall areas.

The following reflectances have been found quite satisfactory as indicated by the test results:

Ceiling — flat white — 85% reflectance
Walls — greyed green — 60% reflectance
Floor — natural finish pine — 35% average reflectance.

These reflectances, as determined by investigation, have been incorporated in the test room for the series of tests under discussion.

Figure 6. Photograph from test position #1, showing uniform brightness distribution.

Desks

The natural finish of 40 per cent average reflectance provided on the mock-up desks of fir plywood was chosen to give the desired brightness ratio of less than 2:1 between a typical visual task of 70 per cent reflectance and the desk top. The visual task is simulated by the test plates of 70 per cent reflectance shown in the figures. The desk top is tilted at 10° with the horizontal, a compromise between the 20° tilt indicated by body mechanics, and the practical necessity of keeping papers on the desk without sliding.

Desk Arrangement

The desk arrangement shown in Figs. 6, 7, and 8 has proved superior for this classroom to the continuous curve arrangement reported for the Mexia and University Park Schools. This conclusion is warranted by the tests which were made during the earlier part of the current investigation, to determine the most effective desk arrangement.

It should be emphasized that desk arrangement is an individual matter for each basic room shape and window arrangement. The custodial staff should be instructed to establish and maintain the basic room seating plan which has been designed for each room, and under no circumstances should desk arrangement be left to the whim of the individual janitor. Proper desk arrangement is a key factor in the classroom visual environment. There is no valid excuse for a bad arrangement.

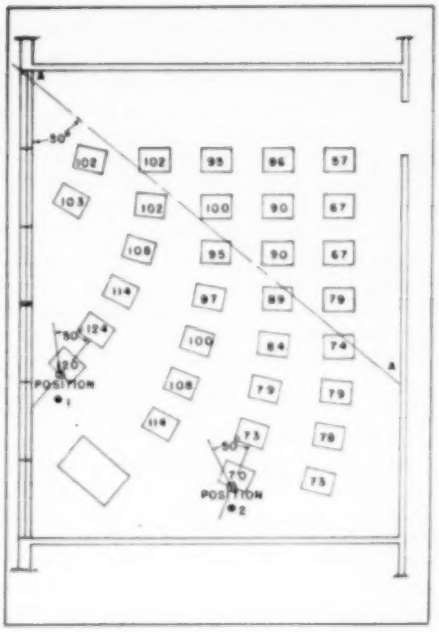

Figure 8. Illumination on desk tops, footcandles; clear glass windows without controls; clear north sky.

Figure 7. Photograph from test position #2.

The recommended pattern for arrangement of desks in a unilaterally lighted room is illustrated in Fig. 8. A line is drawn diagonally across the room at 50° with the window wall, originating at the front of the first window. All desks ahead of this line should be faced straight ahead, with line of sight parallel to the window wall. All desks behind this line should be faced so that the line of sight makes an angle of 50° with the front of the first window, as indicated for the desks at Test Positions No. 1 and No. 2.

TABLE I.—Tests Reported

G2 - 6	Clear glass, clear north sky, no controls on windows. Test made Feb. 17, 1949, 9:55 - 10:57 A.M.
G2 - 9	Clear glass, uniform overcast in north sky, no controls on windows. Test made Feb. 19, 1949, 11:13 A.M. - 12:02 P.M.
G2 - 7	Clear glass, clear north sky, vertical louvers over entire windows. Test made Feb. 17, 1949, 11:30 A.M. - 3:40 P.M.
G2 - 27	Clear glass, clear south sky, sun on windows, horizontal louvers over entire windows. Test made May 9, 1949, 2:10 - 2:48 P.M.
G2 - 24	Clear glass, clear south sky, sun on windows, white translucent shades over entire windows. Test made May 6, 1949, 10:10 - 10:48 A.M.
G2 - 15	Diffusing "Akio" heat absorbing glass, with clear glass vision strip, clear west sky, sun on windows, no control over diffusing glass, horizontal louvers over vision strip. Test made March 3, 1949, 2:30 - 3:30 P.M.
G2 - 26	Clear glass, clear south sky, sun on windows, white translucent shade and vertical louvers over entire windows. Test made May 9, 1949, 10:00 - 10:35 A.M.
G2 - 22	Prism glass with clear glass vision strip, clear east sky, sun on windows, horizontal louvers over entire windows. Test made March 22, 1949, 9:30 - 10:30 A.M.

Illumination Studies

The group of tests reported in this paper is confined to a series of studies of unilateral lighting arrangements, employing window treatments which are either commonly employed already in schools, or are readily available. The tests reported are described in Table I. The data obtained on the quantity and distribution of illumination for the various arrangements is given in Table II.

Sky Brightness

Sky brightnesses which existed at the time of the tests are included for reference. It should be noted in the case of the first three tests that the sky brightness near the horizon is much brighter than that at the zenith for a clear blue sky, whereas the zenith brightness is considerably the higher for a "uniform" overcast. These horizon and zenith measurements are comparable to those obtained by various investigators, notably H. H. Kimball.[7]

The actual illumination on the windows, measured in the vertical plane, has been indicated as of the time of the tests. This vertical illumination on the outside of the windows has been used as the basis of quantitative comparison between window treatments in Table II, since the work of Rapp and Baker[8] indicated it was the most reliable such basis.

It has been the practice in daylighting design in the past to assume a uniform sky brightness of 500 footlamberts, with no ground reflection, which would produce only 250 footcandles incident on the vertical windows. It will be noted, however, that the non-sun exposures in Table II had from 433 to 911 footcandles incident on the windows. In the light of the tests here reported, as well as the data of Kimball and others, it appears more reasonable to base daylighting design on a value of 500 footcandles incident on the windows. This is particularly true of the "overcast" days, most of which were found to give more than 500 incident footcandles. Consequently, for non-sun exposures, the quantitative results have in some of the later columns headed "standard sky" been adjusted to the common base of 500 incident footcandles on the windows, to permit quantitative comparisons.

The incident footcandles for the various sun exposures has varied about 4000 footcandles, which has been arbitrarily taken as the quantitative base for comparison purposes on the sun exposure tests, in the columns headed "standard sky"

Illumination Data

The tests indicated that for all window treatments except one the illumination at every point in the room had a value greater than the 30 footcandles recommended in the American Standard Practice for School Lighting,[9] with daylight alone as the source of light. The average illumination in the rooms has been well above the 30 footcandles recommended. Fig. 8 shows illumination on the desks for a typical test. It is true that on occasion the amount of illumination has fallen lower, but on the basis of our observations

TABLE II.—Illumination Studies

Test No.	Avg. Sky Brightness, Footlamberts At Hor.	Avg. Sky Brightness, Footlamberts Zenith	Vertical Illumination on Windows, Footcandles	Avg. Illumination on Desks,* Footcandles As Found	Avg. Illumination on Desks,* Footcandles Std. Sky	Min. Illumination on Desk,* Footcandles As Found	Min. Illumination on Desk,* Footcandles Std. Sky	Illumination Diversity, Max./Min.
G2 - 6	1190	240	450	82.2	91	51	57	2.17
G2 - 9	1071	1725	911	196	107	96	53	5.01
G2 - 7	1095	295	433	53.3	61	23	28	2.61
G2 - 27	1873	2000	3150	64	81	37	47	3.46
G2 - 24	2008	2200	3864	62	64	30	31	4.77
G2 - 15	2328	442	4694	245	209	80	68	6.93
G2 - 26	1900	1000	3272	37	33	15	14.3	3.05
G2 - 22	2658	425	6233	162	104	91	58	3.3

*The 1948 "American Standard Practice for School Lighting" gives as current recommended practice for "Classrooms—on desks and chalkboards—minimum Footcandles—30."

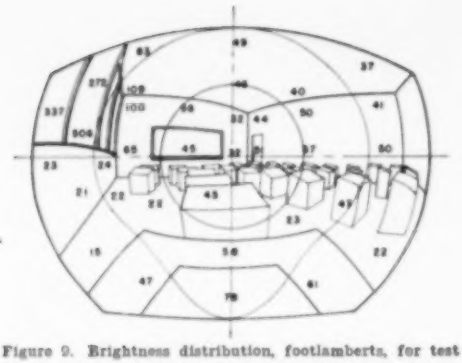

Figure 9. Brightness distribution, footlamberts, for test position #1, horizontal line of sight; lighting conditions as in Figure 8.

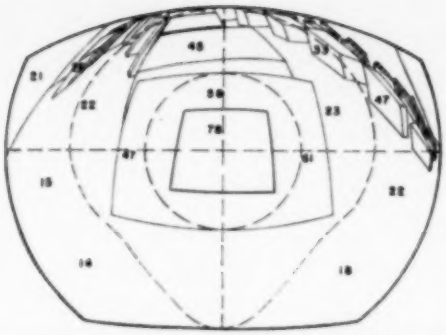

Figure 10. Brightness distribution, footlamberts, test position #1, heads down view; lighting conditions as in Figure 8.

in Dallas at least, it can be said that there is little need for supplementary lighting during the normal school hours for a good daylight design.

The ratio of maximum to minimum desk illumination in the various tests has also been surprisingly low. It will be noted that this illumination diversity varies from 2.17 as a minimum, to only 6.93 as a maximum. The highest value was for the diffusing heat absorbing glass with sun, and can be attributed to the semi-diffuse character of its light transmission. The second highest value was for clear glass with an overcast sky and is attributable to the relatively high zenith brightness of such a sky. In general, the low values of illumination diversity substantiate the work of Ives[10] and his associates, which indicated the importance of interflections from walls, ceiling, and floor in building up the illumination near the inside wall of the room.

It is apparent from the tests that a good daylight design which correlates properly the seating, decoration, and window treatment, will give excellent results in terms of amount and uniformity of illumination on the desks over a wide variety of outside light conditions. Furthermore, it will do so with a unilateral lighting plan, which is the most economical arrangement for many schools.

Brightness Ratios

The typical brightness distributions shown in Figs. 9 through 12 correspond to the illumination distribution shown in Fig. 8. The importance of the proper seat orientation in the production of a favorable brightness pattern is readily apparent from the four typical fields of view shown. The importance of the floor reflection factor in the "heads down" positions is also apparent from Figs. 9 through 12, while the two photographs of Figs. 6 and 7 demonstrate forcibly the importance of the reflectances of walls and desks.

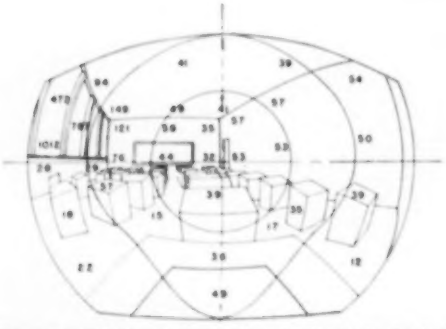

Figure 11. Brightness distribution, footlamberts, for test position #2; horizontal line of sight; lighting conditions as in Figure 8.

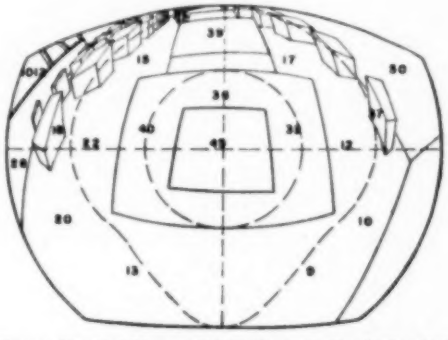

Figure 12. Brightness distribution, footlamberts, test position #2, heads down view; lighting conditions as in Figure 8.

TABLE III.—Brightness Ratios

		Brightness Ratios						
		0° - 30° Zone		0° - 50° Zone		Entire Field		Window/
Test No.	Position	Max./Task	Task/Min.	Max./Task	Task/Min.	Max./Task	Task/Min.	Adjacent Surface
G2 - 6	Up	1.24	2.1	2.22	2.1	11.2	2.94	21.6
Pos. #1	Down	1.0	1.67	1.0	2.62	1.1	3.9	No window
G2 - 6	Up	1.6	2.88	3.4	2.88	23.0	2.76	36.0
Pos. #2	Down	1.0	1.34	1.0	4.15	21.0	5.4	36.0
G2 - 9	Up	1.62	1.58	3.0	2.45	42.2	2.7	28.0
Pos. #2	Down	1.0	1.71	1.0	5.5	12.2	5.5	28.0
G2 - 7	Up	2.14	1.4	3.38	1.5	21.7	2.33	21.7
Pos. #2	Down	1.0	1.35	1.0	4.66	10.9	4.66	21.7
G2 - 27	Up	1.30	1.87	8.20	3.0	11.6	3.4	12.0
Pos. #2	Down	1.0	1.34	1.0	4.73	8.36	4.73	12.0
G2 - 24	Up	1.47	1.46	5.36	3.11	17.9	2.11	12.1
Pos. #2	Down	1.0	1.32	1.0	3.66	6.96	3.66	12.1
G2 - 15	Up	1.21	2.33	2.67	2.90	5.05	0.50	9.17
Pos. #2	Down	1.0	2.07	1.0	6.58	4.53	6.58	9.17
G2 - 26	Up	1.60	1.37	4.8	2.27	15.9	2.70	18.9
Pos. #2	Down	1.0	1.30	1.0	5.27	7.07	5.27	18.9
G2 - 22	Up	1.28	1.53	7.1	2.11	9.34	2.37	9.94
Pos. #2	Down	1.0	1.50	1.0	3.93	5.52	3.93	9.94

At the time this is written, the only official specifications of favorable brightness patterns have been in terms of brightness ratios. The most recent of these is that contained in the American Standard Practice for School Lighting. This Standard Practice contains the following table:

Recommendations for Limits of Brightness Ratios in Schoolrooms

(Rooms used by faculty or pupils for educational purposes)

	Ratio
a. Between the "central visual field" (the seeing task) and immediately adjacent surfaces, such as between task and desk top, with the task the brighter surface*	1 to 1/3
b. Between the "central visual field" (task) and the more remote darker surfaces in the "surrounding visual field" such as between task and floor.....	1 to 1/10
c. Between the "central visual field" (task) and the more remote brighter surfaces in the "surrounding visual field," such as between task and ceiling**.....	1 to 10
d. Between luminaires or windows and surfaces adjacent to them in the visual fields.....	20 to 1

*Chalkboards and some art and shop tasks are illustrations of cases where the reverse ratio of 1 to 3 may apply.

**These ratios apply for areas of appreciable visual size as measured by the solid visual angle subtended at the eye. Luminous areas on luminaires are generally small in size in this respect. For the brightness limitations of luminaires . . .

(Certain parenthetical references to other portions of the Standard Practice have been omitted from the foregoing quotation. R. L. B.)

The brightness ratios measured in the various fields of view reported here are given in Table III. In comparing the brightness ratios found, with those recommended in the American Standard Practice for School Lighting, it can be assumed that the 0° - 30° zone corresponds to item (a) of the Standard Practice table, and that the 0° - 50° zone corresponds to parts (b) and (c) of the table taken from the Standard Practice.

Every brightness ratio shown within the 0° - 30° and 0° - 50° zone falls within the recommendations of the Standard Practice if it can be considered that the first footnote in the table taken from the Standard Practice applies to the "heads up" position. *In every case, for the heads down position, the visual task has been the brightest area in the 0° - 50° field.*

There are other interesting conclusions which could be drawn from the data presented, but which will be omitted for the sake of brevity. It should be obvious at this point, however, that the intelligent use of building materials commercially available, such as steel windows, clear, diffusing and heat absorbing glasses, translucent shades and light reflecting Venetian blinds, etc., can produce visual environments which fully meet all the recommendations of the American Standard Practice for School Lighting. What is more important, if such design for daylight is incorporated in the original architectural design of the building, it can be had at little more, and possibly at no added cost.

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DISCUSSION

BERNARD F. GREENE*: The author and his colleagues should be commended for their sound test procedures and the clear and concise method of presentation. The test results effectively illustrate what a well planned daylighting design can yield.

Now, with these test results, and with other particular test results as background, I believe we should concentrate on applying known mathematical procedures — and establish daylighting application on a general basis. If we are to proceed further with problems of engineered daylighting application, tools should be made available to the architect and engineer, so that window arrangements can be designed for Dallas, New York or any location, to yield a given illumination level and brightness contrast.

In concluding, I should like to suggest that the author include the value of ground reflectance — as it affects the daylight reflected within the room from sidewalls and ceiling.

W. E. FOLSOM**: Publication of Recommendations for Limits of Brightness Ratios in Schoolrooms in the current "American Standard Practice for School Lighting" is a natural stimulus toward the development of a variety of ways of achieving the desired results.

The author of Daylight in Classrooms has studied the suitability of some of the more commonly used means of daylight control with interesting results. From the author's statement that, "Every brightness ratio within the 0°-30° and 0°-50° zone falls within the recommendations of the Standard Practice . . .", it is indicated that, with proper seating arrangement, decoration will go far to achieve recommended brightness ratios. This may also raise the question of whether brightness ratios and footcandles provide a complete criterion for appraising schoolroom lighting. Some educators consider that a moderate component of direct light from the upper portion of the windows is desirable to provide vertical illumination for modeling contrasts when three dimensional objects are being used by the students.

A comparison of brightnesses shown in Figure 11 with results of a similar test made at Rosedale School in Austin, Texas (No. L-16) under similar conditions, but with optical control at the windows, shows comparable footcandle readings and brightnesses except that ceiling and upper side wall (secondary light source) values are shown as lower in Figure 11. This indicates a higher percentage of total light flux reaching the desks from the window area.

Figure 1 indicates that the test house is located on what appears to be a gravel finished roof. This would provide an exterior of higher reflectance than would be normally encountered, which may affect brightness reading on ceiling and upper walls, making them slightly higher than they would normally be.

The author's mention of the problem of ventilation serves to emphasize an important factor. There is a definite need of giving more study to ventilation as an integral part of all daylight control problems.

The author states that Figure 8 shows a desk arrangement more desirable than previously reported. Desk arrangement is a very important part of the schoolroom environment problem. An enlargement of this paragraph would be interesting and of real value.

The paper states that, "in Dallas at least, it can be said there is little need for supplementary lighting during normal school hours. . . ." Table I indicates that all tests involving light control were made under conditions of "sun on windows," except G2-7, which had a "clear north sky." Neither Dallas nor any other major U. S. city can claim all days "sunny." The paper does not apparently present data to substantiate this statement.

It appears to the discussor that this paper is a valuable appraisal of daylight control methods commonly available — that further study should be given to various combinations of configured glass and suitable louvers. In other words, that daylight control in schoolrooms (and offices) is a problem of which new and important solutions are possible.

LEONARD V. JAMES*: There is much of interest in this paper giving the first results of Prof. Biesele's researches on daylight controls. In preparing the 1948 revision of the American Standard Practice for School Lighting, our committee on school lighting found a real need for such studies and reports and it is to be hoped that the author and others will continue to record both quantitative and qualitative observations on the availability and control of natural lighting.

It is unfortunate that, of the eight conditions discussed, all are with a clear sky but one and for this one the vertical illumination on the windows was 911 footcandles. Under such conditions, and considering also the expanse of window area and the height of the ceiling and window head, the conclusion that "there is little need for supplementary lighting during the normal school hours" is not surprising. Having lived in Austin, Texas, it is the speaker's belief that further studies, even in Dallas, will disclose situations which, in spite of the favorable daylight described, will indicate the desirability of having supplementary lighting — probably sufficient at times to provide virtually all of the illumination required.

Mention is made of the use of diffusing glass for the portion of the window above six feet from the floor, giving a satisfactory brightness pattern. A word of warning should accompany this comment. Such glass, even without direct sunlight, can be exceedingly bright as suggested by the author's brightness distribution charts— Figures 9, 11 and 12. Unless the control device in use completely screens the glass, the practical result would be in effect that of introducing brightness areas comparable to a normal sky directly into the outside schoolroom wall.

There has been comment about the light reflected into the room from the adjoining building roof. Even with grass or other treatments having as little as 10 per cent

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reflectance, this influence can be of considerable magnitude because of the size of the reflecting area. When planning the daylighting section of the standard practice, Mr. L. B. Perkins, Chicago architect, suggested the use of wide window sills having a high reflectance. The idea was not included because it was not desired to stipulate the sill height — in the study here reported the sill height was 42 inches, above the normal eye level of the pupils. Also, some of the committee felt the effect on the room illumination would be inconsequential. A check, however, disclosed that a 12-inch sill, 32 feet long, as for this test room, would intercept 160,000 lumens when 5000 footcandles are delivered to it. If a reflectance of 60 per cent is maintained and half of the reflected light is delivered into the room, this would be the equivalent of the combined output of six indirect luminaires of 80 per cent upward delivery of light, each equipped with a 500-watt incandescent lamp.

LELAND H. BROWN*: This paper contains excellent quantitative data on daylight classroom illumination and brightness distribution. It merits careful study by anyone concerned in the design of buildings for the utilization of daylight for interior illumination.

As an illuminating engineer and a teacher I consider the scientific orientation of the desks excellent. However, many educators are pressing the fad of "flexible seating" in classrooms. When followed, this fad often results in children being seated so as to face the windows! Furthermore children, even when their desks face the front of the room, are as apt to look towards the windows as in any other direction. Therefore the brightness studies of a classroom should include the visual field with the greatest range of brightnesses. This usually is the visual field of a person seated clear at the rear of the room in the row of desks next to the inner wall, with the person looking towards the window at the front of the room. Had this visual field been included in the author's study, I believe the high sky brightnesses as seen through the front window even with the north exposure would have made shading or louvering of the clear glass windows quite necessary. This in turn would have lowered the illumination in the room to the point where either bilateral lighting or artificial lighting would have been necessary to maintain adequate illumination throughout the school day.

The comments on "standard sky" conditions etc. bring out the need for comprehensive quantitative data covering hourly and seasonal variations of outdoor illumination and sky and cloud brightnesses for the different climatic conditions that exist over the entire United States. Until such fundamental data on daylight are available, the full value of application studies such as these of Professor Biesele can not be realized.

W. J. ARNER**: Prof. Biesele's paper is excellent and substantiates the findings of Ives and of Greene that with high reflectances from walls and ceiling, illumination levels due to daylight from windows are raised toward the rear of a room and illumination diversity throughout the room is decreased. With high reflectances on walls, ceiling and floor, and with the proper seating arrangement, good visual environments can be obtained in a classroom unilaterally lighted by daylight.

By measuring brightness ratios for both "Heads Up" and "Heads Down" positions of the pupils, he covers practically all of the seeing tasks encountered in a classroom. One can see that brightness ratios in the "Heads Down" position could be improved with a higher reflectance factor on the floor but a factor of even 35 per cent may be difficult to maintain.

Pupils need the relaxation of distant vision just as much or possibly more than office workers. I do not think that this paper clearly shows the desirability of a 42-inch sill height as compared to some other lower height which would afford distant vision and which would better fit structural limitations.

Biesele clearly points out the limitations of one type of diffusing glass in windows, but leaves one to wonder just when fixed vertical louvers might be useful.

Results of the study he has planned for bilateral lighting systems may be even more interesting than his study of unilateral daylighting.

E. W. CONOVER*: It is stated that window sill heights below eye level would introduce disturbing areas of high brightness in the periphery of the visual field. Low sill heights are used frequently on the west coast and, since the view might be grass or foliage, it seems reasonable that the brightness would not be too disturbing. Would this be of an appreciable visual size and could it not be shaded if disturbing?

Table II shows but one test, G2-26, having illumination on the desks below the recommended limits. The sunlight controls were white translucent shades and vertical louvers. A comparison of this with Test G2-27 indicates that Venetian blinds alone are much better and entirely adequate. In this connection do you concur with me that vertical louvers are not a commercial product readily available at little added cost?

From Table III it appears that Fig. 9 to 12 are for Test G2-6. The ratios seem to work out correctly when using the brightness of the chalk board as that of the task for heads-up position. Is the chalk board considered to be the task for this condition?

It is quite apparent that a beneficial visual environment is obtained only when seating arrangement and the brightness pattern of room surfaces are coordinated with the fenestration. The necessity for washing windows is usually recognized. It should be emphasized that, for continued satisfactory visual environment, the light reflecting room surfaces must also be maintained at as nearly the original condition as practical.

R. W. MCKINLEY**: It is a pleasure to acknowledge Prof. Biesele's contribution to the ever-growing store of data on daylighting design. This subject is of personal

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as well as professional interest to all of us. We all use daylight in our homes, offices and plants while the children are at their school desks.

Because Prof. Biesele has now made and reported on careful studies of several daylighting techniques, he would render a service by evaluating the various systems studied on the basis of performance, and maintenance convenience. If significant cost figures are available they would be of interest also.

The extent of his work is such as to mark him an authority in the field and as always, authorities disagree. For example, it would seem appropriate for Prof. Biesele to take up the following conclusions reached by Prof. L. H. Brown of Stanford University as a result of similar work reported in 1939 and listed as reference 5.

In contrast to the point of view expressed here, Prof. Brown states: (and I quote)

> White cloth shades are not suitable on sun exposures.
> High Sky Brightnesses require shielding at all times of skylight from the normal line of sight of the children.
> On winter days, artificial light is needed on the inner side of the room to supplement the daylight, [even] when the upper two feet of window are exposed.
> Present types of venetian blinds require hand setting for effective light control and hence are not very effective.

In the past year, I have spent a great deal of time with architects and school authorities from coast to coast and in Canada. In all areas, dissatisfaction with presently available shades and blinds is loudly voiced. Despite their limitations, projecting canopies seem to be preferred because they are easier to maintain. Years of practical experience indicate that to be even partially effective, shades and blinds must be installed, adjusted during use, cleaned, removed, repaired and reinstalled again and then replaced at fairly frequent intervals. Because of these costly problems, the school people tell me they want to eliminate them completely even in visual education rooms, which must be blacked out.

While I realize that this paper is reporting a laboratory test, I think we would all like to have Prof. Biesele's comments on this practical phase of the subject. The most important limitation of the paper seems to me to be the omission of concurrent consideration of the visual field of a teacher or pupil facing the glass from the front of the room. Specific experience in the past year convinces me that we cannot do a satisfactory job if we do not provide for bi-directional visual fields. Since all of these results are for a visual field, assumed unidirectional, I think they must be carefully qualified.

Finally, I should like to point out the fact that the reference to the work of Dr. Baker, Director of the Pittsburgh Corning research laboratories, is not entirely clear. As part of Dr. Baker's study of the performance of various types of clear glazing and glass block fenestration, Dr. Baker found that a cell used in conjunction with a sphere with aperture in the fenestration plane would give results consistent within about 10 per cent of the average reading, but that a vertical cell used along (as in this study) would give results that varied from 30 per cent below to 60 per cent above the average. Quite possibly Prof. Biesele has all of the information requested but was unable for lack of space to include it. I hope these questions will afford him an opportunity to complete the story which surely is well begun.

W. C. Randall*: The impression looking at Fig. 8 — Illumination on Desks Tops — is that the arrangement of the desks is wasteful of floor space. Granted that the desks should be oriented 50° from a line to the front corner of the windows, is it possible to do that and get in a number of desks more akin to the number normally put in a room of that size? The usual number of desks, I would gather, would be 38, that is five rows of 8 or 40 less two desks to make room for the teacher's desk. I have a slide showing desk arrangement which I feel accomplishes the overall objective of good seeing and incorporates equivalent use of space as the generally used layout. Would Prof. Biesele please comment on this arrangement? I am assuming that the number of desks in the room was not based on cutting down the number of children in classes to approximately 30 but I would like your comment on that also.

References (8) Rapp and Baker, and (10) Ives, indicate the author might have made some check between the results of their work and his, particularly on footcandle intensities. Could some statement be made as to the areas of agreement or deviation, particularly on the percentages of increase in the back of the room due to reflection from correctly decorated walls and ceilings?

In Table III — Brightness Ratios — brightness contrasts are shown exceeding that set up in the Recommendations for Limits of Brightness Ratios in Schoolrooms." Would the author say that generally speaking controls such as Venetian blinds would correct the situation or that the areas were not of "appreciable visual size" as allowed in the Recommendations?

R. L. Biesele, Jr.**: The wide interest in daylighting for schools which the discussion of this paper has indicated is pleasing. Some of the questions raised in the discussion have been at least partially answered by other discussors. Certain other questions seem to require an answer here.

Measurements

All measurements of illumination and brightness were made with a Luckiesh-Taylor Brightness Meter, except the quantitative check readings made with a Weston color-corrected, but not cosine-corrected, photocell instrument located on a desk in the center of the room to establish a quantitative base for each test. Illumination measurements were made by measuring the brightness of a diffuse test plate of known reflectance, and converting to footcandles.

The illumination incident on the windows was determined similarly, with the plate held flat against the outside of the window. This technique determines the illumination incident on the window with an accuracy quivalent to that obtained with the Rapp and Baker sphere and photocell.

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**Author.

Overcast Sky

Several discussors have indicated quite correctly that the sun does not always shine in Dallas. Our tests have included many overcast sky conditions, which were not included in the paper because of space limitations. However, it has been interesting to note that the majority of the overcast days encountered during the test program have actually produced higher levels of illumination incident on the windows during school hours than were produced on the average by a clear sky without sun on the windows. This emphasizes that the Weather Bureau data on sunny and cloudy days is not a reliable indicator of the quantity of daylight available in an area. I endorse Professor Brown's comment concerning the need for more comprehensive quantitative data on the availability of natural light in the various climatic areas of the United States.

There are times, everywhere, of course, when there is insufficient daylight for classroom seeing tasks. This, coupled with the increasing use of classrooms at night, makes a high quality electric lighting system a necessity in any school.

Roof Reflectance

In reply to the question asked by Mr. Greene, Mr. Folsom, Mr. James, and Mr. McKinley, the reflectance of the gravel roof on which the test house is located varies from 12 per cent to 20 per cent, with an average value of 15 to 16 per cent. This is in the general range of ground cover commonly found around school buildings, such as green grass — 5 to 10 per cent, dry grass — 10 to 20 per cent, barren soil — 8 to 20 per cent, and macadamized surfaces — 10 to 15 per cent. The roof, incidentally, extends only ten feet to the west and five feeet to the north of the test house, but farther to the south and east.

Seating Arrangement

The seating arrangement employed is a compromise between facing the child as much away from the window area as possible, and avoiding undue body shadow on the desk. When the angle between window and line of sight can be made greater than 50° without undue body shadow, as is the case in front of the diagonal line A-A of Figure 8, it is desirable to take advantage of the fact. Mr. Randall's suggested seating plan fully meets the visual requirements as determined by this investigation while permitting several more seats in the room than does the author's arrangement. Still other seating plans might be developed which would also meet the visual requirements as stated in the paper.

Prof. Brown's comment with regard to the fad for "flexible seating" is well taken. The ideal, of course, would be a room in which children or teachers could face in any direction without adverse or glaring brightness patterns. However, to the author's knowledge, no daylight control methods yet devised will reduce the window brightness sufficiently to make this possible without also reducing the illumination excessively.

Sill Height

Proper sill height for a classroom is a question still subject to determination. The author and his associates have investigated various fields of view found in their tests by means of both the Harrison Glare Rating and the Logan Flux Analysis. In both these analyses the window area at the far left of the field of view assumes importance. As will be noted in Figures 9, 11, and 12 a reduction in the sill height would materially increase the amount of solid angle subtended at the observer's eye by the window. It is questionable whether the additional light admitted by a lower sill would compensate for the disturbing brightness introduced into the field of view, although this is a matter on which opinions might reasonably differ.

Controls Employed

Mr. McKinley's quotations from the earlier study by Professor Brown must be taken in the light of the difference in the conditions between the author's tests and Prof. Brown's. For example, the white cloth shades reported by Professor Brown were unfilled white canvas. Those used by the author were Tontine #500 and are not directly comparable. Professor Brown's comment regarding "shielding of skylight from the normal line of sight of the children" requires a definition of the normal line of sight. I have chosen to consider that 50° or more away is not in the normal line of sight. I quite agree that white sunlit clouds and some hazy skies are extremely bright and may require some form of shielding such as that provided by the vertical louvers reported in one of the tests. In answer to Mr. Conover and Dr. Arner, this comment in Professor Brown's paper was one reason for including vertical louvers in the testing program, even though they may not be "commercially available" at present.

The common varieties of shades and Venetian blinds do leave something to be desired from the standpoint of maintenance. However, certain mechanical improvements have been introduced in recent years which tend to simplify this problem and I believe that others can be expected. It was not the purpose of this paper to attempt to improve on these devices, but to report on what could be done with those now available.

Mr. Folsom's comment regarding the difference in brightness pattern produced in Figure 11, as compared with the unpublished Test L-16 of the Rosedale school, indicates a situation which should be expected. The two situations are not directly comparable, since Figure 11 is of a room with clear glass windows and clear north sky with no sun on the windows, while Test L-16 is of a room with optical control in the window area and with sun striking the windows from a clear southwest sky.

Effect of Reflections

As suggested by Mr. Randall and Mr. Greene, the tests reported on, and others which form a part of the investigation, have indicated a close agreement with the work of Rapp and Baker and that of Ives on the effect of the

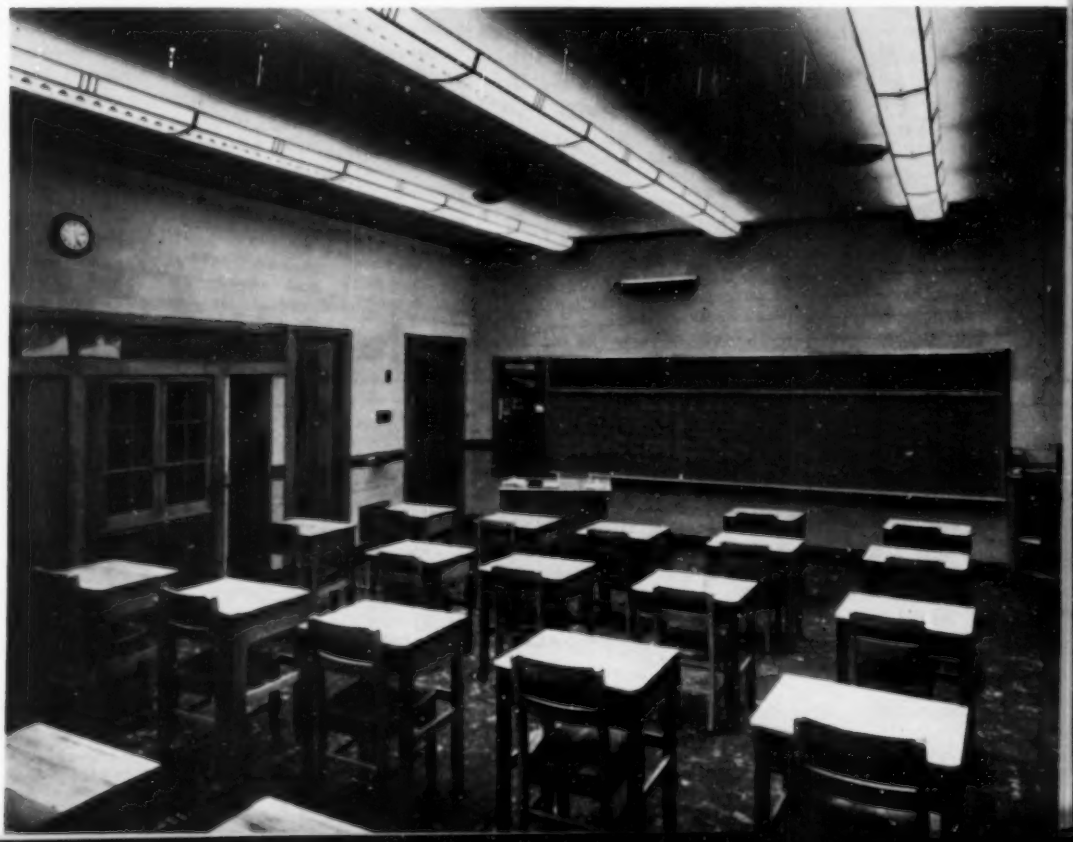
reflection factors of room surfaces on the distribution of horizontal illumination within the room. The increase due to inter-reflections within the room is quite material, particularly near the inside wall, and should be taken into account in daylighting design.

Daylighting Design

Based on our investigations to date, and on the literature which is available, it appears entirely possible that further investigations of the effect on the light distribution within the room of window size and placement, light control devices at the windows, and reflection factors of room surfaces may make it possible to work out superior methods of daylighting design. There are indications that this might even be developed into a lumen method of daylighting design. Such a design technique would certainly be welcomed by anyone faced by daylighting design problems.

Typical Classroom, Herbert Hoover Grade School, Camp Hill, Pennsylvania

Planned lighting integrated into a planned environment is featured in the recently opened six-room grade school at Camp Hill, Pa. All six rooms have three continuous rows of seven two-lamp 40-watt shielded fluorescent fixtures per row, producing an initial average illumination level of 70 footcandles. The anticipated maintained value is of the order of 50 footcandles. The planned environment contains the ingredients necessary to utilize the lighting to best efficiency and at the same time provide comfort and quality. Data on the environmental features are: Walls: light flat pastels, 50% to 60% reflectance. Ceilings: acoustic tile, 75-85%. Dado: medium flat pastels, approx. 40%. Other trim: natural finish, medium reflection. Floor: asphalt tile, approx. 35%. Chalkboard: light green. Daylight control: double roller shades. Desk tops: natural finish; dull, approx. 50%. Bactericidal irradiation: three 30-watt units per room. Tack board: medium reflection flat finish. Brightness balance is reported as excellent. Illumination is evenly distributed with less than 10% variation through the work area. Data submitted by E. W. Kelsey, Pennsylvania Power & Light Company, Harrisburg, Pa.



Black Light for Marking Blue Fabrics

By BRUCE J. JENSEN

Ultraviolet "black light" activating a fluorescent powder produces a glowing pattern for embroidery machine work.

PROBLEMS are encountered in lighting an embroidery machine, that are not too frequently found in other industrial operations. Rather different techniques were employed, therefore, in lighting such a machine at the Bright Infant's Wear Company, Bayonne, N. J.

In the use of an embroidery machine the operator works from a paper pattern. The design to be embroidered is first drawn on the paper, then the lines of the pattern are punched out with a perforating tool. The perforated sheet is placed over the artilcle to be embroidered and heavily dusted with a chalk powder. When the paper is removed, the design appears on the material as a dotted powder line.

The glare problem usually encountered with the highly specular material involved was solved by the use of fluorescent powder instead of chalk dust as a means of indicating the pattern to be followed by the embroidery machine operator. In conjunction with the fluorescent powder a source of ultraviolet "black light" is used instead of the conventional light source. Under these conditions the pattern itself glows and becomes very easy to see.

A moderate amount of general illumination, approximately 10 footcandles, is necessary in order that the operator may see the thread, machinery, and associated equipment, and at the same time relieve the contrast which would result if the surrounding visual field were dark.

The "black light" source used is a 15-watt, T-8, 360BL fluorescent lamp housed in a flexible extension arm fixture, covered by a filter sleeve to absorb the visible radiation.

General lighting is provided by fluorescent industrial reflectors using two 40-watt lamps each.

Production of a luminous, glowing pattern on the material has been an outstanding success. Since the seeing task is made immeasurably easier, there have been many favorable results:

1. The work can be done much faster, thereby increasing production.
2. More intricate patterns can be embroidered than were possible with the old system, thereby creating a product with more sales appeal.
3. One of the troublesome features of the old method of marking the pattern was that a heavy deposit of chalk powder remained on the fabric. It was a somewhat difficult and time-consuming process to clean the material before shipping it to the customer. Under the new method very little fluorescent powder is needed to reveal the pattern, and there no longer exists any problem of cleaning garments before shipping.
4. Anyone can now operate the embroidery machine whereas formerly only a few specialists could do this exacting work.
5. A "break-in" period was formerly necessary whenever a new pattern was put in production. After this the operator worked partly from memory. Now it is immediately apparent what turns a new pattern takes and no "break-in" period is necessary.
6. There is another advantage from the fact that very little fluorescent powder is needed for marking the pattern. This is evident when dealing with loosely woven fabrics. With such fabric, it is possible to delineate the pattern on four or five pieces of material at one time, with the pieces stacked one over the other. The loose weave allows enough of the powder to fall through and show a luminous pattern line under the influence of the "black light."

MR. JENSEN is Assistant Sales Manager, Electric Dept., Public Service Gas & Electric Co., Newark, N. J.

Modern Photometry of Fluorescent Luminaires

By G. A. HORTON

This paper describes a versatile distribution photometer capable of handling all fluorescent fixtures including the eight-foot slimline luminaires. A versatile photoelectric instrument for measuring luminaire brightness is also described.. An improved wide-range, zero-resistance photocell circuit is presented. Suitable portable photometers for the measurement of localized lighting characteristics are mentioned. Contemporary methods of fluorescent photometry are discussed. Practical aspects of fluorescent photometry are mentioned. Useful references are included.

FLUORESCENT luminaires are now manufactured in lengths up to slightly over eight feet. The measurement of the candlepower distribution of these long, narrow luminaires involves no basic principles of photometry that are unused or unknown. The problem is the application of standard photometric procedure to this type of luminaire.

Candlepower Distribution Measurements

The most basic photometric principle involved is the "inverse square law" which is based on a point source of light. However, fluorescent luminaires are extended linear sources of light and it has been found that for high precision in candlepower measurement the test distance should be at least five times the maximum dimension of the luminaire.[1]

Because of the limited sensitivity of the light-measuring equipment used in commercial photometry, it is desirable not to exceed greatly the required minimum test distance. Therefore, the test distance should be variable depending upon the maximum dimension of the luminaire being tested.

It is necessary that the measuring apparatus be so located with respect to the luminaire that the light emitted in any direction may be measured. In other words, the measuring apparatus must be effectively rotated about the luminaire in all directions and at distances up to approximately 40 feet. To accomplish this by actually moving the measuring apparatus about the luminaire would require the luminaire to be mounted at the center of a room over 80 feet in all directions which is rather obviously out of the question in nearly all cases. If this cannot be done, then the luminaire must be so mounted that it can be rotated about its own center and the light emitted in any direction directed upon stationary measuring apparatus. The photometer described in this paper is designed to accomplish this result. It is illustrated with a four 40-watt luminaire in Fig. 1. During the candlepower distribution measurements it will be seen that the fluorescent tubes lie in a vertical plane at all times, the effective light center of the luminaire being at the junction of the two axes of photometer rotation. Suitable angular scales are provided for orientation of the luminaire to any combination of horizontal and vertical angles.

When luminaires having both downward and upward light are being photometered, a special yoke is used which permits measurement of the

Figure 1. Arrangement for measuring lower hemisphere light.

A paper presented at the National Technical Conference of the Illuminating Engineering Society held September 20-23, 1949, French Lick, Indiana. Author: Westinghouse Electric Corporation, Lighting Division, Cleveland, Ohio.

upward light without blocking from the vertical support member of the compound rotator proper. This is illustrated by Fig. 2.

The light output characteristics of fluorescent lamps are affected by ambient air temperature.[2,3]

In the photometer being described, the luminaire during candlepower measurements is mounted with the fluorescent tubes in a vertical plane. In this position it is readily apparent that the air currents about the lamps will be considerably different than when the luminaire is mounted in the normal hanging and burning position, especially with luminaires of the industrial type utilizing closed top reflectors. This means that the light output of the lamps during testing is not the same as normally obtained. A correction factor must, therefore, be applied to the measurements to compensate for this difference and the correct factor must be obtained for every test and sometimes for every different vertical candlepower traverse.

For the initial stabilizing period, the luminaire is oriented in its normal operating position until thermal stabilization is reached. This may require several hours from a cold start. This may be determined by a photocell or footcandle meter placed directly beneath the luminaire (See Fig. 4). At the end of this burning period, to establish the zero degrees (nadir) reading, the luminaire is quickly turned so that the reflector opening or lower face of the unit is vertical and the lamps horizontal and a photometer reading immediately taken. It has been found that there will be no appreciable change in light output between the normal operating and the measuring position for about thirty seconds. The lamps are then operated to constancy in the measuring position, this sometimes requiring one-half hour or longer. The difference between this latter reading and the reading made immediately after placing the face of the luminaire in a vertical plane is used as a correction factor for all photometer readings throughout the distribution in this vertical plane. Likewise, corrections are made in all other vertical distribution planes in order to correct all values to correspond to normal burning position of the luminaire.

Figure 3. Arrangement for normal position stabilization.

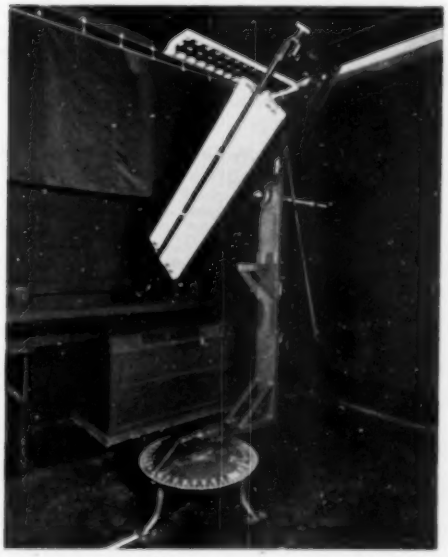


Figure 2. Arrangement for measuring upper hemisphere light.

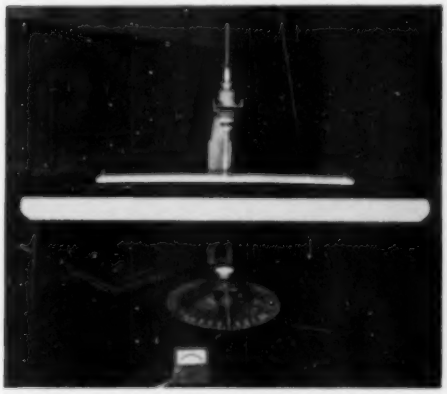


Figure 4. Slimline normal position stabilization.

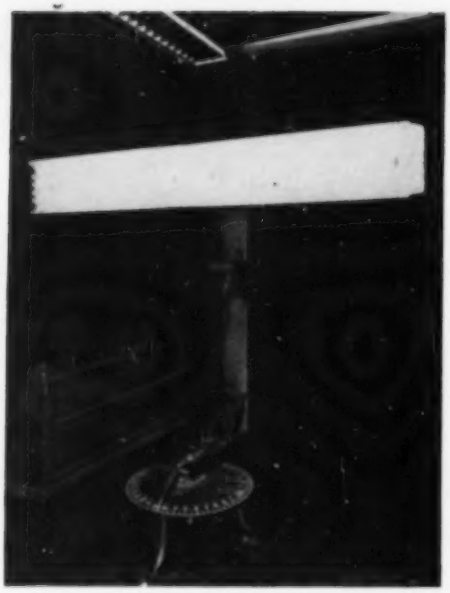


Figure 5. Slimline luminaire in measuring position.

The method of obtaining the correction factor in the case of commercial type luminaires is shown in Fig. 3. To facilitate obtaining this correction factor for industrial type luminaires with no upward light, the photometer was constructed with a hinged upright member as illustrated by Figs. 4 and 5. These figures also serve to illustrate that the photometer is capable of handling the eight-foot slimline luminaires.

To determine light output, measurements are taken in a number of vertical planes, with reference to normal hanging, and computations are made. The usual procedure is to measure candlepower distribution in three vertical planes; parallel to lamps (0°), 45° to lamps, and normal to lamps (90°), averaging both sides of the fixture. In the case of units of more concentrating or asymmetric distribution, the average of five vertical planes may be necessary to obtain a representative result. These additional vertical planes are taken at $22\frac{1}{2}$° and $67\frac{1}{2}$° to the lamp axis. The candlepower values are measured at the vertical settings of 0°, 90°, and 180° from nadir and at intervals of 10° beginning at 5° and ending at 175°. Additional readings may be taken at more points if necessary, to determine the exact shape of the curve.

Calibration of Photometer

The relative method of photometry is used and the method of calibrating the photometer is illustrated in Fig. 7. The lamps alone are burned horizontally one above another, in open air, with blackened separators between them to eliminate interreflections and mutual heating. They are operated from the ballasting equipment in the luminaire, by means of extension cords (see Fig. 6) equipped with the regular fluorescent lamp bases for conveniently and quickly plugging into the luminaire sockets. The light measuring device is the same distance from the bare lamps as during the candlepower distribution measurements and the reading obtained normal to the lamps represents a

Figure 6. Calibration of photometer with 40-watt T-12 lamps.

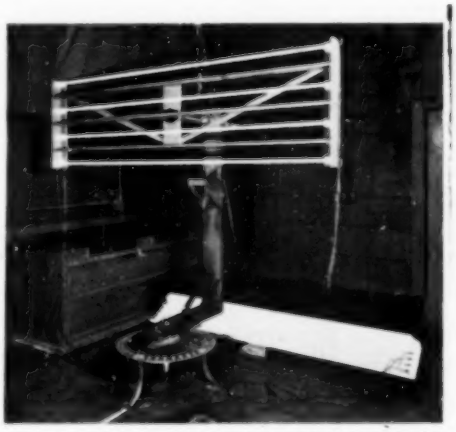


Figure 7. Calibration of photometer with 96-inch slimline lamps.

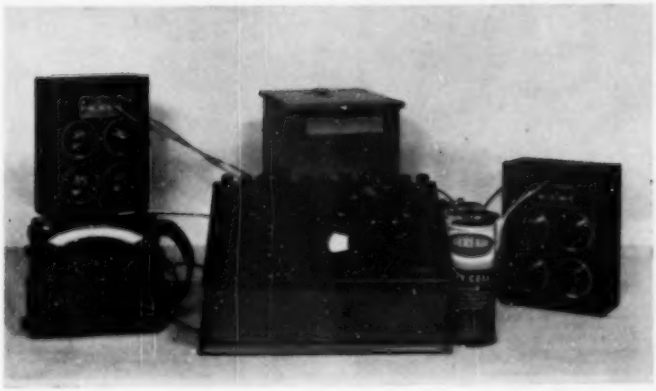


Figure 8. Current balance and accessories. ***(Published by permission of Rubicon Co.)***

candlepower value equal to the sum of the rated candlepowers of the lamps in a direction normal to the lamps. Different size calibrators are available for different lengths of lamps. The lumen-horizontal candlepower ratio of 9.25[4] has been verified in a number of laboratories and may be used with confidence.

Any of the commercially available barrier-layer photocells may be used for the candlepower measurements.[5]

For linear relationship of cell response to incident light and for a minimum of fatigue and temperature influence, the barrier-layer cell should be operated under simulated short circuit conditions.[6, 7] This is accomplished by use of a "Current Balance" (See Fig. 8), the circuit diagram of which is shown in Fig. 9. Photometric readings are made on the ten-position dial switch and the continuously adjustable 14-inch slidewire (marked 220 scale divisions, Fig. 9) of the same general construction as employed in portable precision potentiometers. An effective scale length of approximately 125 inches is thus provided, subdivided into 2020 divisions. As commonly used, the slide wire is set to some convenient value, the photocell exposed to the bare lamp or calibration illumination, and the two rheostats R_1 and R_2 manipulated until the galvanometer indicates no deflection. When this is so, the potential difference at the galvanometer terminals must be zero and the conditions are equivalent to a short circuit so far as the photocell is concerned.

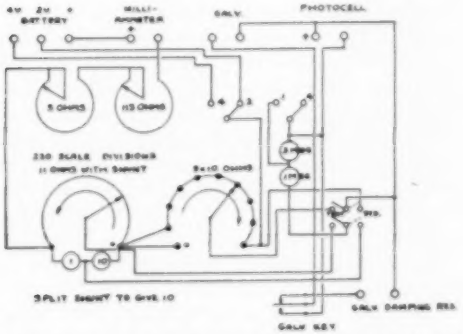


Figure 9. Circuit diagram of current balance. ***(Published by permission of Rubicon Co.)***

With the circuit arrangement as in Fig. 9, photocell currents ranging up to approximately 40 microamperes may be handled. Extremely low currents may be handled by reducing the applied battery voltage and by employing a galvanometer of adequately high sensitivity to indicate the condition of balance. Higher currents may be balanced if voltages higher than 4 volts are applied to the battery terminals.

Reducing the applied voltage may be accomplished by introducing an additional resistance in the battery circuit. It proved convenient to have it adjustable and a decade resistance was used.

In order to cover all ranges of illumination ordinarily encountered, three galvanometers were selected with nominal characteristics as follows:

Coil resistance 350 ohms, sensitivity .012 microampere per M.M., period 2 seconds, C.D.R.X. 2500 ohms.

Coil resistance 60 ohms, sensitivity .005 microampere per M.M., period 5 seconds, C.D.R.X. 600 ohms.

Coil resistance 1500 ohms, sensitivity .0006 microampere per M.M., period 6 seconds, C.D.R.X. 40,000 ohms.

Figure 10. Photoelectric brightness instrument.

In order to accommodate galvanometers of differing critical damping resistance it was found convenient to use a resistance decade box.

The milliammeter shown in the circuit diagram is used to check the constancy of the current through the slidewire.

Measurement of Luminaire Brightness

This is one of the most important measurements to be made upon luminaires since brightnesses affect the visibility of objects and the comfort of the observer in sustained critical seeing.[8]

Brightness instruments used in the past have been visual illuminometers and these are, of course, beset with all the difficulties of visual heterochromatic photometry.[9] Fluorescent lamps are manufactured in a variety of colors almost none of which match the color temperature of the visual comparison lamp. The usual way to change the field size was to vary the test distance. These instruments have been adequately described in the literature.[10]

The I. E. S. Guide for the Photometric Testing of Fluorescent Luminaires—1948,[11] requires that certain specified areas of the luminaires be scanned. The brightness instrument described in this paper was designed accordingly.

The international definition of brightness is: "Brightness (Symbol:B). The brightness of a surface in a given direction is the quotient of the luminous intensity in that direction by the projected area."[12] From this, we see that the brightness of a given area is directly proportional to the candlepower.

Photocells measure illumination and not brightness. Illumination is inversely proportional to the square of the distance from the source to the light sensitive surface of the photocell.

Then, assuming a source of large area of uniform brightness when viewed from a particular direction, a photocell will measure the brightness in that direction when placed at any distance from the surface if the cell is so shielded that it will be illuminated by a portion of the surface having an area directly proportional to the square of the distance from the source to the cell.[13] Such an instrument, properly calibrated, is accurate when the open end of the tube is held against a translucent surface emitting light, such as a diffusing enclosing globe. However, in the case of surfaces which are bright due to reflected light, it is obvious that the open end of the tube cannot be held against the surface since it would interfere with the incident light. When the open end of the tube is at a distance from the bright surface, the area being scanned increases due to the finite area of the light sensitive surface of the photocell.

The final design of the photoelectric brightness instrument is shown in Fig. 10. A rectangular cross section was decided upon since one of the apertures required is $\frac{1}{4}$ by 4 inches.[11] The greatest width of aperture required is one inch. A tube 24 inches long was selected as the best compromise between loss of sensitivity due to distance of the photocell from the surface being scanned and the angular difficulty mentioned in the preceding paragraph. This longer length of tube also reduces cosine law error[14] of the photocell, since the light will strike the photosensitive surface within a smaller solid angle. The removable sections of the tube containing the scanning apertures were made with a long taper so that it would be possible to aim the instrument within small angles of the surface being scanned. This is another reason for the rectangular cross section instead of circular cross section for the main body of the instrument. The apertures chosen were 1 inch by 1 inch, $\frac{1}{2}$ inch by 2 inches, and $\frac{1}{4}$ inch by 4 inches. The inside cross section of the body of the instrument is $1\frac{1}{2}$ by $4\frac{1}{4}$ inches. The inside of the instrument was lined

with black velvet so that only the direct light from the aperture would reach the photocell. The photocell chosen had a rectangular light sensitive surface measuring approximately $\frac{3}{4}$ by $1\frac{1}{2}$ inches. An aperture of this same size was fitted into the rear of the tube just in front of the photocell. The photocell can then be removed, the eye of the operator placed in the photocell position and the surface being measured scanned visually before actually taking a photocell reading. This assists in selecting the proper size of aperture.

When taking brightness measurements of the luminaire the brightness instrument is mounted on a photometric bench (Fig. 11) such as was used in the past for visual photometry. Adjustments are provided for moving the brightness tube up and down and a protractor is used for orienting the tube to lateral angles. This angular adjustment together with that provided by the candlepower distribution photometer, makes it possible to scan the luminaire at any angle both crosswise and lengthwise.

To measure the photocell current a deflection type of galvanometer having a zero left and 100 scale divisions was used. The characteristics of this instrument are as follows:

Coil resistance — 60 ohms.
Sensitivity — .005 microampere per M.M.
Period — 5 seconds.
C.D.R.X. — 600 ohms.

Since it was found necessary to cover a wider range of currents than the galvanometer scale range can accomodate, it was found convenient to use an adjustable shunt[15] to afford a selection of galvanometer sensitivities in known relationship to one another. This shunt is of the Ayrton type with the additional provision that the resistance of the galvanometer as viewed by the photocell is the same for all multiplier positions. The multiplier values are 0, 1, 10, 100, 1000 and Infinity or short circuit.

In order to keep the sensitivity of the brightness instrument as high as possible, it is desirable to use a photocell without a spectral correction filter. On the other hand, it may be desirable to use a filter if the light from the fluorescent lamps is altered in any way by spectral selectivity of the finish on the luminaire or any enclosing translucent diffusing material.

The brightness instrument was tested by measuring with each aperture the brightness of a piece of diffusing glass which was uniformly illuminated from the rear. These readings were found to check each other within 2 per cent.

The maximum brightness of the luminaire is measured in the zones 0° to 45°, 45° to 60°, 60° to 75°, and 75° to 90° from nadir or 0° both perpendicular and parallel to line of lamps. Apertures are selected to suit the dimensions of the bright area being measured. In general, the maximum brightness is at the lowest angle in the zone.

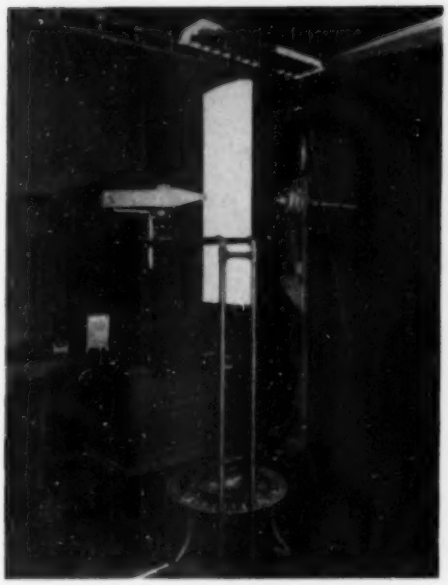


Figure 11. Brightness instrument in use on photometric bench.

Calibration of the Brightness Instrument

Since the photometric method used is relative and it is not necessary to know the actual light output of the test lamps in order to calibrate the photometer, it is also convenient to calibrate the brightness instrument from the test lamps at the same time the candlepower distribution calibration is made.

In the past, manufacturer's lamp information has contained the statement "Maximum values at center of lamp perpendicular to lamp", or "Approximate candles per square inch measured at the brightest square inch in center of lamp", when referring to brightness ratings. These data would not be suitable for calibrating the brightness instrument.

However, it is understood that the data now published refers to the average brightness of the lamp; *i.e.*, the brightness integrated across the lamp diameter in the center lengthwise. These data are calculated by the method of Linsday[16,17] and are suitable for calibrating the photoelectric brightness instrument.

Since the largest diameter of fluorescent lamp is the T-17 or 2⅛ inches, it is convenient to use a special aperture one inch wide and 2⅛ inches long for calibration. When calibrating for lamps of different diameter than one inch, the reading should be divided by the diameter of the lamp in inches.

The methods and equipment available for measuring illumination in footcandles developed on localized working planes has been described in the literature[18,19,20,21,22,23,24,25,26,27] and will not be treated here.

Contemporary Methods

One laboratory is known to use a method of calibration and of determining the nadir (0° vertical) candlepower of the luminaire with the test lamps mounted in normal burning position using a mirror to obtain the necessary test distance. The candlepower distribution data is obtained in the usual way. This should eliminate most of the variables in obtaining the calibration and temperature effect data but it appears considerable special equipment would be necessary in the way of variable lamp spacings to simulate different luminaires.

Another laboratory uses a large ferris wheel arrangement, the wheel being 19½ feet in diameter. The maximum test distance of 25 feet is obtained with mirrors and all measurements may be made in normal positions, the luminaire or lamp being suspended at the center of the wheel. Lamps and luminaires up to 5 feet in length may be accommodated.

Still another laboratory suspends the luminaire from the ceiling in the normal hanging position. The vertical angles are measured and the photocell is mounted on a quadrant of 10-foot radius. The maximum test distance obtainable is ten feet.

As far as is known, the equipment mentioned in the above three paragraphs is not capable of handling the eight-foot slimline luminaires due to various mechanical limitations and lack of adequate test distance.

One laboratory calibrates the photometer using one lamp at a time, the light being measured from four different positions 90 degrees apart around the tube, the readings being averaged. This is done to help eliminate the slight non-uniformity of light output around the lamp.

With regard to the photoelectric brightness instrument, it is believed that the accuracy is improved by utilizing a tube 2 feet in length rather than the one foot tube previously mentioned in the literature.[1] The shorter tube was probably sufficiently accurate for measuring emitting surfaces but probably not for reflecting surfaces.

The Luckiesh-Taylor Brightness Meter has been used for measuring the brightness of fluorescent luminaires, but has the disadvantages of the difficulties of heterochromatic photometry and that the field size is difficult to control. Also, its calibration is direct rather than relative.

Mr. G. T. Winch of Wembley, England, states:[28] "Concerning the method used in photometering fluorescent luminaires, in view of the fact that in a majority of indoor installations they are operated at distances too close to the working plane to enable the illumination to be calculated from the polar distribution, we make measurements of illumination in one or more working planes. These measurements are made with visual or photoelectric portable types of illuminometers."

Summary

The photometer described is capable of handling all fluorescent luminaires including the eight-foot slimline fixtures.

The photometric method described permits of the use of a room of ordinary height and proportions.

The photoelectric brightness instrument described seems preferable to visual instruments. It can be calibrated from the test lamps regardless of their actual light output and can be color corrected if necessary.

Experience has shown the test results obtained with the described equipment to be sufficiently reproducible for commercial purposes.

The candlepower distribution curves and derived data seems to be an excellent method of assessing luminaires and in conjunction with Coefficients of Utilization[33,34] results in an excellent method of application.

Acknowledgments

The author is indebted to Messrs. Edward A. McVeen and Andy Ballas who constructed the compound rotator and brightness instrument and also to Messrs. James A. Klyne and Robert C. Haynes for many valuable suggestions in connection with the design of the brightness instrument.

Appendix A

Practical Aspects of Fluorescent Photometry

3500K white lamps should be used unless otherwise specified.

All fluorescent lamps which are to be photometered should be seasoned for a period of 200 hours.

Lamps should be selected for constant light output for constant voltage input to auxiliary and repeated operation.

Lamps should be selected for uniform color and brightness.

In multiple lamp luminaires, the test lamps should be matched for light output within plus or minus 5 per cent when measured on the same auxiliary.

Measurements made around 40-watt fluorescent lamps indicate that such tubes have uniform light output within 1½ per cent total variation.

Light output values vary for different positions of the fluorescent tube. There may be as much as 2 per cent difference between the tube operated in horizontal and vertical positions.

There may be considerable difference in candlepower for a luminaire with the lamp above or below the reflector. With the lamp up, differences as much as 10 per cent higher may be encountered than with the lamp downward. This, of course, varies with the type of reflector and the amount of heat confined around the lamp.

The lumen-horizontal candlepower ratio 9.25 is an average value. Individual lamps will usually have such a ratio within the range of 9.15 to 9.35. The factor 9.25 was obtained empirically and while it is entirely suitable for conventional shape of lamps, might lead to errors in the case of unorthodox types of lamps.[29, 30]

The test lamps should be operated during the photometric procedure from the ballasts furnished with the luminaire, holding the voltage input the same during both the calibration and candlepower distribution. It is preferable to measure the voltage at the ballast using potential leads, if the voltmeter is situated some distance away.

Lamp circuit pin connections should remain the same throughout the test.[1]

The light-measuring equipment should be checked for linearity by the additive method[31] throughout the entire usable scale and the individual readings should be reproducible within a tolerance of plus or minus one per cent.

Some photocells have been found to vary more widely from linearity at intensities below 0.1 footcandle than above this value. Since color-correction filters cause a loss of sensitivity of as much as 90 per cent, they should be used judiciously.

The dynamic response of a barrier-layer cell is always less than its static response.[32] Even at 120 cycles per second, which is the frequency of modulation of light from fluorescent lamps operating on a supply of 60 cycles per second, the reduction is measurable. Since the eye obeys Talbot's law with high precision, the cell response cannot be exactly equivalent. This is a good argument for the use of the relative method of photometry for fluorescent luminaires.

An important requirement in fluorescent photometry is an alternating current power supply of constant voltage. The light output of fluorescent lamps near the operating point varies approximately as the input voltage to the auxiliary. Since the relative method of photometry is used, changes in light output due to harmonics in the power supply will cancel out, permitting the use of the commercially available static type of resonant circuit and electronically regulated power supplies. A harmonic-free, electronically voltage stabilized alternating current generator has been described in the literature.[5]

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DISCUSSION

RAY P. TEELE*: The author has given a good discussion of the troubles encountered when photometric measurements are made on luminaires designed for use with fluorescent lamps. The figures used to illustrate the paper clearly indicate the size and massiveness of the goniometer required not merely to hold the luminaire but to provide rigidity so the alignment of the goniometer axes is maintained.

Particular attention has been given to the design of the photoelectric brightness meter. The apparent brightness of a surface depends solely on the illumination of the retinal image and this, for a given adaptive state of the eye, depends only on the angular density of the luminous flux which unit area of the surface emits in the direction of the eye. The distance from which the object is viewed is immaterial, since both the flux entering the eye from unit area of the surface and the superficial area of the retinal image vary inversely as the square of the distance and hence the illumination of this image is constant. The brightness meter described has been so shielded that it views a portion of the surface having an area proportional to the square of the distance from the source to the cell. This important design factor has been often overlooked and the meters in which this condition has not been fulfilled should be called "fixed distance brightness meters" or in some cases contact brightness meters" as they must, for accurate results, either be used at a particular distance or in contact with a translucent surface

F. VOELKER**: It is interesting to note that Mr. Horton closely followed the procedures recommended in the 1948 I.E.S. Guide for the Photometric Testing of Fluorescent Luminaires. He seems to have adequately compensated for the variables which his testing methods create.

The photoelectric brightness instrument described is a commendable development, well suited to the purpose. It would, however, seem more reasonable for brightness readings to be taken with the fixture in a normal horizontal operating position rather than in a vertical position. This would eliminate variables in brightness which are caused by heat and lamp lumen changes due to abnormal fixture positions.

The author states that three galvonometers were necessary to cover all ranges of illumination required. Would it not be less expensive and less difficult to use one galvonometer and shunts of the required size to obtain the same results? The maintenance of delicate testing equipment is always a problem and it would seem advisable to reduce maintenance in this manner.

From the author's description, it appears that for each test position the time required would be a minimum of 0.5 hour, plus 2 hours for test period warm-up and stabilizing, plus any time required for measurements. For measurements in the 90-45-0-45-90 degree zones this would involve four correction factors to be established. Therefore, the minimum time required for an industrial reflector test would be in excess of 4.5 hours. For concentrating or asymmetric reflectors or commercial fixtures with an upward component this time would be much greater. This means that where many fixtures of various types must be tested, the time factor and the associated costs involved by this time factor may become the governing factor. This raises the question of whether structural and instrumentation costs to facilitate normal burning position tests in conjunction with mirrors may not be more justifiable for a long range operation where many tests are involved. Perhaps the answer lies in the use of Mr. Horton's methods for lamps in excess of 60-inch length while for lamps of 60 inches or shorter the use of faster testing methods previously developed would be more suitable. In any event, Mr. Horton's efforts to improve fluorescent luminaire testing procedures are a definite contribution to the science of illumination.

W. F. LITTLE*: Experiments at ETL indicated that the hinging method of standardizing the luminaire in the normal to the vertical position was not entirely satisfactory. For this reason the mirror method was adopted and has proven very satisfactory.

The brightness equipment described by Mr. Horton was originally developed at ETL for incandescent photometry in the early thirties and has been used continuously for both incandescent and fluorescent measurements with considerable success.

The procedure described by Mr. Horton for measuring brightness, namely, one square inch, with maximum of four square inches, was discussed by Mr. Darley a number of years ago. It was used at ETL for a short period but abandoned because —

1. The published brigatness value of the tube was neither average nor maximum as based upon the candlepower and projected area of the tube. It is, however, closer to the maximum; therefore, an inch square area in the center of and at various places along the tube seems more representative.
2. To measure the brightness of an area of 1 square inch, the maximum dimension of which is four inches and the minimum ¼ inch, penalizes the unit where a narrow strip of lamp may be seen through a clear cutting or under or over the edge of a louver, ¼ inch of bare tube four inches long would be considered just as objectionable as the entire tube and this certainly is not the case.
3. In spite of the alternate methods recommended by the IES Committee, it is my belief that the majority favor the one inch square area for measuring brightness. At least this should obtain until a definitely superior method is proposed.

At ETL brightness is measured with the equipment using a photocell and low resistance, adjustable microammeter to read directly in candles per square inch. This equipment has proved its worth by giving the operator an overall picture of the brightness pattern as the test is in process, thus explaining what may seem to be apparent discrepancies.

In the Fleur-O-Lier program, brightnesses are measured in a number of narrow zones; therefore, when

*National Bureau of Standards, Washington, D. C.
**Champion Lamp Works, Lynn, Mass.

*Electrical Testing Laboratories, Inc., New York, N. Y.

readings are given at angles of 20°, 30°, 35°, 40° and 45° below horizontal, these readings represent the highest value in each of the narrow zones.

Some thought is now being given to average as well as maximum brightnesses.

G. A. Horton*: The author wishes to thank Messrs. Teele, Vorlander, and Little for their comments, and in particular Mr. Teele for his very constructive comments on brightness measuring instruments.

Replying to Mr. Vorlander the author wishes to state—

1. That no difficulty at all is encountered in making readings of luminaire brightnesses with the fixture in odd positions as these positions are exactly the same as for the candlepower distribution and the same corrections may be applied to the brightness readings as were determined as described in the text for distribution readings.

2. The "Current Balance" described is a universal photometer and may be used for several purposes such as photometric integrators, distribution photometers, beam photometers, reflectometers, footcandle instruments, or anywhere barrier-layer type photocells are employed. Never more than one galvanometer would be required for any one application. The best practice is to select the least sensitive galvanometer that will do the job. High sensitivity can be attained only by sacrifice of other desirable characteristics, such as speed of operation, ruggedness, stability, reproducibility of readings, etc. It is true that by the use of shunts and series resistances the sensitivity of a galvanometer can be reduced to what is requisite for the problem at hand, but this does not add strength to the suspension, shorten the period, or improve the stability of zero reading, and a less sensitive and more steady instrument would yield accurate results with far less exertion and annoyance.

3. As for the time consumed for the various thermal stabilizations required in the photometric method described in the text, the personnel simply have to be given something else to do for these periods.

The time required for photometering fluorescent fixtures varies with the type, some enclosed types requiring no positional corrections at all, to the open industrial units which present the most adverse "chimney effect" conditions.

The photometering of fluorescent luminaires in normal position using mirrors may not be desirable since the reflection factor of a mirror cannot be assumed to be constant at all angles of incidence, and since each mirror must be larger than the light source to be measured, apparatus of this kind becomes very heavy and cumbersome in the case of large sources.

In reply to Mr. Little, the author wishes to point out that a method of measuring brightness in which the photometric field size is restricted by shielding was described by Ives in 1914, the main difference being that the measurements were made by visual instead of physical methods. This appears as reference No. 8 of the paper.

A check of the fluorescent lamp schedules of three large manufacturers has shown the published brightnesses to be average values and as such are entirely suitable for calibrating the brightness instrument as described in the paper. Thus, if the instrument was calibrated using a one inch square area for lamps larger than one inch in diameter, the calibration reading would be too high with the result that brightness readings on the luminaires would be too low. The opposite results would be obtained for lamps smaller than one inch in diameter.

*Author.

Automobile Showroom in Southern California

Another interesting installation to be seen by visitors to the I.E.S. National Technical Conference in Los Angeles next month, is the Don Lee Cadillac showrooms on Ventura Boulevard. In keeping with the "open front" technique, a lighting system had to be designed that would blend in with this form of architecture. Large luminous panels were used. These are 4 ft by 8 ft in size and are semi-recessed. Each lighting unit contains eight 300-milliampere slimline lamps and egg-crate louver panels. Note how the lighting emphasizes the streamline contours of the cars. Average illumination level is 50 footcandles. Consulting engineer for the job was R. G. Ojeda; architect was Duel, Conklin and Coleman, Los Angeles.

TELECAST

LIGHTING NEWS OF CURRENT INTEREST

Summary of Action Taken by Council at June Meeting in New York

The June meeting of the I.E.S. Council, last major meeting of the current administration, invariably faces a very full schedule. The meeting on June 8 this year, at the Roosevelt Hotel, New York City, extended to all-day deliberations, a brief summary of which is given below. Present at the meeting were: C. H. Goddard, President; S. G. Hibben and Walter Sturrock, Vice-Presidents; R. G. Slauer, proxy for R. W. Staud, and Lee E. Tayler, Past-Presidents; A. H. Manwaring, General Secretary; E. M. Strong, Treasurer; R. L. Biesele, Jr., Myrtle Fahsbender, J. E. Mueller, Hoyt P. Steele and M. N. Waterman, Directors; G. W. Beals, I. H. Graves, proxy for F. A. Covington, G. F. Dean, E. H. Lauth, J. S. Schuchert, L. A. Hobbs, proxy for T. H. Shepherd, and W. A. Stannard, Regional Vice-Presidents; A. D. Hinckley, Executive Secretary; C. L. Crouch, Technical Director; Ruby Redford, Production Editor — ILLUMINATING ENGINEERING; and E. W. Commery, R. F. Hastenstein, C. N. Laupp and Carroll L. O'Shea.

Membership Elections

Acting on the recommendation of the Board of Examiners Report, submitted by E. M. Fahey, Chairman, Council approved the election of five full Members. Mr. Fahey's report also included the election of the Board of Examiners of 71 Associate Members and 36 Student Members. Current membership totals are shown in the following tabulation:

September 30, 1949		June 8, 1950
6803	Total Membership	7363
26	Members Emeritus	33*
44	Fellows	41
1521	Members	1650
5048	Associate Members	5311
244	Student Members	368

*Includes 8 Fellows of the Society.

Conference Preprints

In reporting for the Publications Committee, in the absence of E. C. Huerkamp, Chairman, R. G. Slauer indicated the Committee's plan with regard to preprints of the Pasadena Conference papers.

All Conference papers received and approved by a scheduled deadline will be preprinted for distribution at Pasadena, at $1.00 per set. He indicated that it is the Committee's further plan to make available after the Conference, complete sets of all Conference papers, bound in a suitable cover, at a price to be established later.

In further reference to Conference papers, Mr. Slauer indicated that from 50% to 75% of the papers would be published in full in ILLUMINATING ENGINEERING, together with discussion, the remainder to be published as condensations.

New Sustaining Member

Favorable action by Council on the recommendation of the Sustaining Membership Committee, G. J. Taylor, Chairman, elected:

Iowa Power and Light Company
312 6th Avenue, Des Moines 3, Iowa
Official Representative: N. Bernard Gussett

New Chapter Established in Toledo

A formal petition for the formation of an I.E.S. Chapter was presented by W. A. Stannard, Great Lakes Regional Vice-President, on behalf of a group of members in the Toledo area. It was noted that all of the requirements necessary for Chapter status had been fulfilled, and action was taken to approve a Charter for the new group, to be known as the Northwestern Ohio Chapter.

San Jacinto Section Established

On application of the South Texas Section, action was taken to change this Section's name to San Jacinto Section. It was noted that with the subsequent formation of other chapters in South Texas, this name no longer is as appropriate as at the time of the Chapter's founding.

Election of Officers

A. D. Hinckley, Executive Secretary, read the report of the Committee of Tellers, Priscilla Presbrey, Chairman, on the election of national and Section officers. A complete listing of the officers elected as a result of membership ballot is given elsewhere in the Telecast Section, this issue.

Regional Conferences Scheduled

Northeastern Regional Conference
October 26-27, 1950, Hotel Statler, New York City.

Southwestern Regional Conference
Week of March 5, 1951, Corpus Christi, Texas.

South Pacific Coast Regional Conference
Week of March 12, 1951, San Francisco, Calif.

Pacific Northwest Regional Conference
Week of March 19, 1951, Spokane, Wash.

Southern Regional Conference
April 9-10, 1951, Miami, Florida.

Canadian Regional Conference
May 9-12, 1951, Chateau Frontenac, Quebec City, Que.

Midwestern Regional Conference
Week of May 14, 1951.

Great Lakes Regional Conference
Week of May 21, 1951, Cincinnati, Ohio.

Historical Committee Active

S. G. Hibben, Chairman of this committee, reported that a survey and record of the first ten years of the Society's founding and operation, has been prepared for committee approval. He indicated also, that phonograph recordings of four of the earliest Presidents of the Society were being prepared.

Council discussion on this committee's activities suggested cooperation with the Ford Museum of Illuminants at Dearborn, Mich., and special displays in museums celebrating the Society's Golden Anniversary in 1956.

In connection with his report, Mr. Hibben recommended the enlargement of the headquarters library of volumes on illumination indicating this might be accomplished through bequests.

Technical Program

A progress report on the Society's technical committee activities was presented by C. L. Crouch, Technical Director. He noted that the Committee on Illumination Performance Recommendations is making steady progress, with the aid of Mr. Guth, toward a system of evaluation of the limiting brightness of luminaires. Extensive work has been done but considerably more must be carried on before a practical application can be found to all the variations on current fixtures. The special Task Committee working with the Industrial Hygiene Division of the U. S. Public Health Service is making steady progress in writing the text toward development of the booklet, "How to Make a Lighting Survey."

A study committee is under way for the garment industry in New Jersey with the cooperation of Mr. Gomberg, engineer for the International Ladies' Garment Workers' Union. Mr. Gomberg has shown considerable enthusiasm and has contacted a West Coast organization for a possible study in that area.

The period since the last Council meeting has seen considerable activity in relation to other organizations. The American Institute of Architects arranged a Lighting Symposium this year in connection with their National Conference at Washington on May 10, 11 and 12. Mr. Kenneth C. Welch, a familiar figure in I.E.S. committee channels, was chosen moderator since he is active in A.I.A. affairs. A very interesting program was arranged with the following papers delivered:

"The Visual Effect of Basic Light Distribution Patterns"—Howard Sharp.
"Daylighting"—R. L. Biesele, r.
"Dramatic Uses of Light"—Stanley McCandless.
"Basic Factors of Vision"—C. L. Crouch.

The Ohio State University and the Ohio Optometric Association held their Annual Conference at Ohio State University May 14 and 15. Dr. Foote, Executive Director of the National Society for the Prevention of Blindness, and Mr. Crouch were asked to give the feature lectures. Mr. Crouch presented two—"Lighting for Schools and Industry" and "Prescribing Illumination." There was a large group of optometrists present who manifested a great deal of interest in the subject of lighting. A Vision Research Conference was held at Nela Park, April 24 and 25 at which 24 research specialists described their studies. The New York Section of the American Institute of Electrical Engineers held a symposium on light and vision researches at which Dr. Gertrude Rand and Mr. Crouch presented brief descriptions of what had been done and was being done in lighting research.

Home Lighting Report For Laymen

A comprehensive study on "Contemporary Lighting for Modern and Traditional Interiors" prepared by a subcommittee of the Residence Lighting Committee was presented for Council approval by E. W. Commery. The Chairman's report, written in lay language, is intended as a consumer piece of value to the large group who have to do with the design of lighting for the home. Council approved the report for publication, with commendation to the sub-committee and recommendation of widespread reprint distribution.

Montreal Sets Record for Canadian Regional Conference

A new record of attendance and participation was established for the Canadian I.E.S. region in the Conference held at the Mount Royal Hotel in Montreal May 11-13. The total formal registration of 248 persons included 160 I.E.S. members and 24 men guests and 64 women guests; in addition to which there was a casual and transient attendance estimated at 100 persons. Other Canadian regional Conferences have been held as follows: Toronto, 1949; Ottawa, 1948; Montreal, 1944; Toronto, 1943; Montreal, 1942; Toronto, 1941 (first). Source of the registered attendance was as follows: Montreal 129, Toronto 54, United States 19, Ottawa 16, Hamilton 10, Maritime 8, Quebec 7, Winnipeg 5.

Outstanding highlight of the Conference program was the reception and buffet supper given to the I.E.S.ers by Mayor Camillien Houde of the City of Montreal. The affair was, of course, heavily attended and was held at the City Hall in its famous Hall of Honor. This whole affair was carried off in regal manner, with interludes of orchestral music and dancing. Mayor Houde was present in person all evening, circulating through the party and personally conducting interested inspection groups through his executive offices. Other social activities included two heavily attended formal luncheons and the presidential reception, dinner, and dance, all held in the hotel ballroom. At the Thursday noon luncheon, Mayor Houde was present in person to participate and give a personal welcome on behalf of the City of Montreal. I.E.S. Vice-President S. G. Hibben, speaking to the topic "The I.E.S. in Retrospect" reviewed historical highlights of the lighting industry and of the Illuminating Engineering Society since its founding in the winter of 1905-06. At the Friday luncheon, Mr. E. D. Gray-Donald, Vice-President and Chief Engineer of the Shawinigan Water & Power Company spoke to the topic "The Utility Looks at the I.E.S." Mr. Gray reviewed the constructive and cooperative relationship that exists between the Illuminating Engineering Society and the electric light and power industry, and outlined the opportunities for continued constructive cooperation toward the objective of providing better lighting service for more people. Highlight of the special program of entertainment provided for women guests in attendance was the luncheon held Thursday noon at the Ritz Carleton Hotel. The highly successful terminal activity of the Montreal Conference was an inspection trip to the huge Beauharnois Hydro Electric Power generating project of the Province of Quebec, about 25 miles up the river from Montreal. Two bus-loads of I.E.S.ers clambered all over the project from the subterranean turbine levels to the roof-top switching structures, and from the operating room of the present plant to the new plant under construction which will house a dozen new 50,000-hp generating units, approximately doubling the size of the plant. A luncheon served in the cafeteria of the construction camp topped off the occasion.

Wednesday, the day before the tech-

President and Mrs. Goddard receive typical Quebec "habitat" handcraft as a gift of the Canadian Regional Conference. Joe Thomas, Conference Chairman, center, made the presentation at the Region's meeting in Montreal, May 12-13, 1950.

sical sessions started was given over to an all-afternoon meeting of the I.E.S. Council Executive Committee, and to an all-evening meeting of the Local Activities Committee under the guiding hand of Vice-President Hibben. The evening meeting was very generously attended and there was wide and protracted discussion concerning all manner of I.E.S. activities.

At the opening general session Thursday morning, Conference Chairman Joseph Thomas presided. Canadian Regional Vice-President G. F. Dean gave the official address of welcome and introduced President Goddard. Mr. Dean traced the history of the growth of I.E.S. activities in Canada, and pointed to a future of wide opportunity. President Goddard, in his address, reviewed the scope and nature of I.E.S. activities, and pointed up the importance of continuing strong and constructive leadership in the development and maintenance of lighting standards.

Five technical sessions were provided in the Conference program. The first technical session was held Thursday morning under the Chairmanship of A. H. Mendel of Montreal. The Thursday afternoon session was held under the chairmanship of W. B. Fulton of Ottawa Chapter. Friday morning, a general technical session under the Chairmanship of G. M. Whittaker of Hamilton, Ont., Chapter was paralleled by a session on "Light Conditioning the Home" under the Chairmanship of E. F. Wilson of Winnipeg Chapter. A fifth session was held Friday afternoon under the joint Chairmanship of D. R. Webb and Miss D. Beraba of Montreal, devoted to a symposium presentation on light conditioning the home.

Committee Personnel

To the following people goes the credit for the hard work involved in putting on the Conference:

Conference Committee G. F. Dean, Canadian Regional Vice-President, J. Thomas, Conference Chairman, F. P. Labey, Vice-Chairman, R. A. Eshelby, Secretary.
Papers and Program: Duncan M. Jones, Chairman; C. Cathers, J. W. Greenlaw, G. Hopkinson, J. E. Landers, H. Lushington, P. Marchand.
Finance Committee: E. D. Leigh, Chairman; N. B. Chadwick, D. H. Hymers, H. Lushington, R. Martineau, L. G. Scott and J. Walden.
Publicity Committee: W. M. Massie, Chairman; D. M. Haymann, R. C. Herring, T. H. Quipp, O. Sarault, K. I. Stiles, and A. J. Vandervlis.
Registration Committee: W. C. M. Weightman, Chairman; M. J. Cote, H. Lushington, S. McKnight, W. F. C. Nottelman, H. R. Payson, and E. F. Wilson.
Transportation Committee: W. C. M. Luscombe, Chairman; T. W. Birt, H. R. Payson W. F. Nottelman, C. T. Roberts, J. E. L. Walker, J. P. Wilson.
Hotel Committee: W. L. Vincent, Chairman; E. J. Copeland, A. C. de Lery, J. E. Landers, G. F. Mudgett, C. T. Roberts, and E. G. Wimperis.
Reception Committee: H. J. Ward, Chairman.
Ladies Committee: Mrs. R. C. Thomas, Chairman.

Technical Papers Digested

Some fifteen papers comprised the technical program of the Montreal Conference:

1. "Relighting Montreal" by Lt. Col. A. Leduc, City of Montreal.
2. "Adventures in Industrial Illumination" by G. J. Taylor, Day-Brite Lighting Inc.
3. "New Concepts of Light for Merchandising" by D. P. Caverly, Sylvania Electric Products Inc.
4. "Lighting and Child Development" by Dr. D. B. Harmon, Austin, Texas, Technical Consultant, F. W. Wakefield Brass Co.
5. "What's New About Light Sources" by W. Sturrock, General Electric Co., Nela Park.
6. "The Optical Effects of Various Colours and Illuminants" by C. R. Conquergood, Canada Printing Ink Co. Ltd.
7. "The Quality of Fluorescent Units" by D. C. Borden, Northern Electric Co.
8. "Daylighting in Homes" by Prof. J. Bland McGill University.
9. "Glass—Its Place in Home Design and Decoration" by J. Webster, Pilkington Glass Ltd.
10. "Watts Lost" by R. E. Bailey, Thomas & Betts, Ltd.
11. "Light Up with Colour" by D. S. Catton, Canadian Paint, Varnish and Lacquer Association.
12. "The Decorator's Problem" by L. Mulligan, Interior Decorators Society.
13. "Solutions to Special Lighting Problems" Miss Myrtle Fahsbender, Westinghouse Electric Corp.
14. "Lighting for Living" by Miss Janet S. Reynolds, Sylvania Electric Products Inc.
15. "Rooms with a New Look" by Miss Margaret Lidstone, Canadian General Electric Co. Ltd.

A digest of these papers reflecting their essential substance is given in the following paragraphs.

Relighting Montreal

Lieutenant Colonel Leduc reviewed the salient features involved in Montreal's progressive program of modernizing its street lighting system. He pointed out that, in the Fall of 1947, the Montreal Street Lighting System "consisted of the usual admixture and variety of circuits, lamps and fixtures, which for the past 20 or 30 years seemed to be the attribute of any large and self respecting city ... foremost among our problems was the presence of direct current circuits ..." accounting for some 70 per cent of the system. To give his listeners a tangible concept of the size of the 700-mile street lighting project, Leduc pointed out that it was the equivalent of the distance from Montreal, Quebec, to a point 200 miles south of Washington, D. C., with one lighting unit every 225 feet of this distance.

Of the 11,000 original units, the plan called for 7,500 to be removed and replaced by modern units at the rate of approximately two new units to one of the old. When completed, the city system will represent 8000 kilowatts of connected load representing 30 million kilowatt-hours per year or the equivalent yearly expenditure of 5,000 average-sized residences ... cost of operation and maintenance overall is expected to approximate something more than one thousand dollars per night."

Incidental to the improvement of the lighting, Mr. Leduc pointed out that part of the program was to simplify the system of supply circuits, to result in just two main groups: (a) an underground system entirely of the a-c series-type with the units mounted on ornamental standards owned by the city; (b) an overhead system which will be a-c multiple-type, with the units owned by the city but mounted on poles owned by the Quebec Hydro-Electric Power System," a solution which we find very economical in

view of the conditions prevailing in Montreal and in spite of the fact that this imposes a certain limitation upon the attainment of full efficiency from light sources."

The basic plan of the Montreal Street Lighting program is for incandescent units except for certain strategically important and heavily traveled high-speed roads linking with key bridges. These special roadways will be clearly identified to the motor traveler by the use of lighting units of a peculiarly characteristic quality, such as high intensity mercury vapor units.

Industrial Illumination

Mr. Taylor stated that in most factory areas there are many instances seeing tasks "are more critical than in offices, schools, drafting rooms, and the like ... this means but one thing — quality of lighting should approach the ideal." He expressed the view that in many factory areas, the shielding of light sources, the control of brightnesses, the proper direction of upward components of light, etc., are of even greater importance as elements of proper industrial luminaire design than in some areas served by commercial luminaires. Mr. Taylor expressed the belief that in spite of the stress that has in recent years been placed upon the importance of eliminating glare and harsh shadows, "too little has been done throughout industry as a whole properly to correct these undesirable factors, both of which are negative and rob workers of ease of seeing."

The prescription of specific levels of illumination in terms of footcandles is still a good method, but the prescriber must have full knowledge of these footcandles with relation to footlamberts. Both go together in weighing quality of lighting, they cannot and must not be separated, warns Mr. Taylor. Some industrial tasks require only a very high level of general illumination. Others require moderate levels of general illumination together with high levels of supplementary lighting. Still others require strong directional lighting with high footlambert brightness, to bring out defects in certain problems of inspection.

Mr. Taylor pointed out that while fluorescent lamps have provided a marvelous lighting tool for industry, sight must not be lost of the fact that incandescent lamps and mercury lamps also play a very important part in solving industrial problems; "too often these latter two light sources are overlooked in regard to lighting economy, under the assumption that any one of the three sources will do an equally good lighting job. Here again it must be understood that cost of a lighting system in terms of dollars alone does not prove it to be the most economical system. On the contrary, the most expensive system with highest operating cost may be by far the most economical if workers can see better and thereby work faster with fewer errors."

At Mayor Houde's Civic Reception in Montreal. Front row, usual order: Duncan Jones, I.E.S. Director. C. H. Goddard, I.E.S. President. Mayor Camillien Houde, Walter Sturrock, I.E.S. Vice-President. S. G. Hibben, I.E.S. Vice-President. Second row: E. M. Strong, I.E.S. Treasurer. Mrs. Goddard, and directly behind her, Mrs. Strong. Mrs. Joe Thomas. Mrs. Hibben. Third row: Mrs. G. F. Dean. Joseph Thomas, Chairman of the Conference. Mrs. Jones. Top: A. Dexter Hinckley, I.E.S. Executive Secretary and G. F. Dean, Canadian Regional V.-P.

Lighting for Merchandising

"There is no other field in illumination work today that is changing more rapidly than store lighting," according to Mr. Caverly, who further stated that "... The techniques used, even as recently as three or four years ago, are changing as a result of architects' and designers' demands for drama and interest in a lighting system. We find an abundance of contrast through application of dark ceilings in conjunction with incandescent downlights and cove lighting. We find in large department stores, a system of integrated sales units with one lighted somewhat differently than the other, but tied together through architecture and a modest general lighting system, supplemented with high level special lighting methods.

"The use of incandescent lamps is becoming more and more pronounced, and the use of lighting fixtures, as such, becoming less pronounced—through built-in systems, concealed downlights and fluorescent equipment.

"The overall picture is a healthy one, since it means flexibility with respect to ideas, and a greater use of the imagination and less of the slide rule. There is little in the Society's literature today that tells people "how" this can be done, but steps are being taken by the Store Lighting Committee to rectify this situation. Luminous ceilings are being used to some extent, but rather than provide a monotonous flat expanse of luminous area above, they are being broken up by opaque elements, color or some other means of providing pattern and texture to the ceiling.

"It appears that the next couple of years will be most interesting and challenging ones to the illuminating engineer specializing in store lighting."

Lighting and Child Development

To a packed audience, the largest of the conference, Dr. Harmon presented his well-developed thesis that "the organic child has just so much energy to expend ... this energy must satisfy the child's basic need in staying alive; conversion of his food into usable chemical forms, protection against infection and disease; energy required by activities and adjustments demanded by the child's environment; energy demands of just plain growing." Dr. Harmon pointed out that only a limited amount of the child's energy is really free for activity, and thus that when environmental demands exceed the energy free and available for meeting them, the need is met by depriving some other vital need of its energy requirement. In such cases, growth is reported as suffering first.

Dr. Harmon pointed out that although

bodily growth is inherently a balanced process, its centers, at any given time, are always at the center of the greatest bodily activity. In other words, the child's body, or bodily systems, tend to grow along the lines of stress induced by various activities, in order to reduce these stresses. If the environment sets up centers or lines of stress not fitting the alignment of inherent and normal growth forms, the result is structural warping. As the child continues to grow and function in such surroundings, the final result is asymmetrical or unbalanced body structures deviating performances, or physical or psychological lesions and disabilities.

Light Sources

In a demonstration-discussion, Mr. Sturrock reviewed some of the more significant of the newer developments in light sources, all of which have been reported in previous issues of Illuminating Engineering. Most colorful feature of the demonstration was the parallel comparison of draperies, flowers and other commonplace objects as viewed under the currently common 4500°K white in contrast with the much more natural effect of the new so-called de luxe white. For more information, including technical data, on these new fluorescent lamps, see pages 37-38 of the January 1950 issue of Illuminating Engineering.

Quality of Fluorescent Units

In presenting a searching discussion of the important question of the relationship existing between price, quality, operating efficiency, and user satisfaction, with reference to fluorescent luminaires, Mr. Borden literally and all but physically took a fluorescent fixture apart and critically analyzed its basic materials, and minute component parts. What he said was, of course, not news to professional lighting people, but it was presented in a dramatic fashion and called attention to the wide disparity currently existing between the dependable luminaire information in the possession of professional lighting personnel, on the one hand, and the understanding of the user and his attitude toward the luminaire quality-versus-price question.

Excerpts: "In selecting fluorescent fixtures, 'getting the most for the money' does not mean merely the most fixtures, but also the most in appearance, the most light with the least glare, the least maintenance and replacement, the best lamp light, and the least power consumption . . . one must realize that evenness of distribution, low glare, minimum number of fixtures per footcandle, may be more important than the price of fixtures or any other individual selling point." With reference to brightness and shielding "sometimes it seems that public understanding of fluorescent has slipped back to where incandescent was twenty years ago when the footcandle meter (or candlepower meter) began to be a sales tool and when intensity was about the only criterion, brightness and glare being seldom considered. . . . I.E.S. folks knew all about these, but customers' questions indicate that, as engineers and salesmen, we still have a big job to do before Mr. Buyer learns to spend his lighting dollars to his own best interest."

With reference to mechanical considerations, "... before you fall in love with a fixture, *stop and take it to pieces!* Give critical consideration to the metals, plastics, glass, fastenings, components, and finishes used, even critical attention to shipping containers.

Light Conditioning the Home

A symposium of eight topics was grouped under this general heading, embracing two technical sessions.

Speaking from the standpoint of an architect, Professor Bland discussed "Daylighting in Homes." He stated emphatically that homes can and should be designed so to place the various rooms as to make the most appropriate and effective use of natural light. This without in any way belittling the need and desirability for providing adequate illumination from electrical sources to supplement daylighting and to make areas useful at night as well as by day. He mentioned that one of the most challenging problems with reference to either natural or artificial illumination was the sudden transition from a bright exterior to a relatively dark interior and pointed out that the traditional architectural device for softening this transition was the use of a covered porch on the exterior of the entrance and an especially well-lighted hallway just inside. He suggested that living rooms should be located south and west for bright afternoon living; bedrooms east, and libraries northwest, etc. In speaking of the undesirable effect of glare and contrast as related to window areas, Professor Bland pointed out that there is very much less undesirable glare and contrast from very large modern "picture windows" than from smaller and narrow window openings.

In discussing "Glass and Its Place in Home Design and Decoration," Mr. Webster described the history of architecture as being the record of a constant struggle for light. He outlined and reviewed the many architectural and decorative uses for glass of different types in the modern home, and exhibited many different interesting samples. He described the "ideal window" as being an area "which would use plate glass in the lower vision area and light-directing glass in the upper or non-vision area to spread the incoming light throughout the room." He placed various samples of this type of glass before a projection

Civic Reception tendered all delegates of the Canadian Regional Conference May 13, by His Worship, the Mayor of Montreal.

lantern to demonstrate their effect graphically.

Mr. Bailey re-emphasized the well-established arguments in support of adequate wiring for any lighting job. He described the electric wiring system as being "that portion of every lighting installation that is behind the scenes."

Mr. Catton speaking to the topic "Light Up with Colour" discussed the relationship of colour and lighting as a team combination working together for human comfort and the avoidance of fatigue. He spoke very strongly in favor of "an increasingly closer understanding and co-operation between architects, colorists, decorators and illuminating engineers."

In discussing "The Decorator's Problem," Mr. Mulligan reviewed the history of light and laid great stress upon the opportunity for and the desirability of greatly increased Canadian initiative and development in the field of light and lighting. He urged "the necessity for architects to get into lighting design beyond the matter of specification of so many electrical outlets per room, etc." With reference to the manufacturers' traditional claim that they "make what the customers want," Mr. Mulligan strongly expressed his belief "that both architects and manufacturers could to mutual advantage be educated to furnish real leadership in lighting rather than just resorting to the modifications of old gas-light fixtures, or just plain ultra-modern fixtures intended to be startling rather than effective ... they need good designers well trained, and daring enough to use new materials and to develop new ideas for effective and attractive (luminaire) design which very well could be profitable alike to manufacturers and users."

Getting right down to cases, on how to use light effectively in the average home, Miss Fahsbender, Miss Reynolds and Miss Lidstone each presented profusely illustrated talks reflecting specific solutions that have been worked out for a wide variety of home lighting problems.

Midwestern Regional Conference Enjoys Milwaukee "Gemuetlichkeit"

The Milwaukee Chapter of I.E.S. conducted its first regional conference May 17-19, a meeting of Convention stature sponsored by the Midwestern Region. Close to 200 delegates attended the excellent technical sessions at the Astor and Knickerbocker Hotels, and enjoyed Milwaukee's famous "gemuetlichkeit." The entire conference was under the able direction of I. L. Illing.

In the absence of President Goddard, attending another conference of overlapping dates, four Past-Presidents were guests of honor. I.E.S. Past-Presidents attending were, in chronological order of their presidential years, S. B. Williams, G. K. Hardacre, R. W. Staud, and L. E. Tayler.

Deputy Controller for the City of Milwaukee, John Kalupa, opened the meeting with an address of welcome in which he stressed the value of heavy industries in the greater Milwaukee area. He pointed out that it was second to the much publicized beer industry. He noted also that Milwaukee led the nation in street lighting, and that standards set up by the City of Milwaukee have been accepted as the National Standard by the Standards Association.

Technical Papers Presented

The excellent and well attended technical program of the Mid-Western Regional Conference consisted of the following outstanding papers:

"Let's Get Up-to-Date on Light Sources" by Carl Jensen, Westinghouse Lamp Div.

"Advantages of New Light Measuring Instruments" by R. J. Diefenthaler, G. E. Lamp Dept.

"How Manufacturers are Meeting Today's Market," by S. B. Williams, Sylvania Electric Products Inc.

"What an Architect Expects from a Lighting System" by Roger Kirchhoff, State Architect, State of Wisconsin.

"New Concepts on Lighting for Merchandising" by C. M. Cutler, G. E. Lamp Dept.

"Today's Home Lighting Needs Planning" by Miss Edith Buckholz, Westinghouse Lamp Div.

"Progress Report on School Lighting" by Prof. R. Putnam, Case Institute of Technology.

"Color—An Integral Part of Lighting" by Ralph M. Evans, Eastman Kodak Co.

"Lighting Our Public Buildings" by J. M. Ketch, G. E. Co.

"What's New in Street Lighting" by Warren Edman, Line Material Co.

"How to Present the Street Lighting Story" by G. G. Wheeler, Northern States Power Co.

"Lighting for Recreation" by Merle Keck, Westinghouse Elec. Corp.

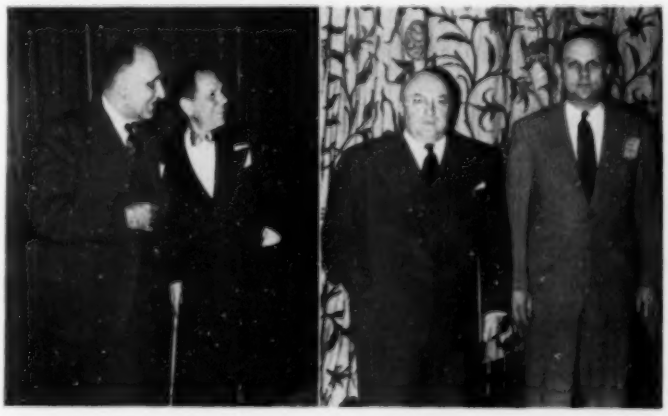
"Our Industry Needs Planned Lighting Promotion" by James T. Coatsworth, Edison Electric Institute.

"Let's Do Something Good" by Carl Bremicker, Northern States Power Co.

By courtesy of Line Material Co. of Milwaukee an inspection of Mitchell Field airport lighting was made from an airplane by the interested members. Demonstrations of the high intensity airport lighting were shown both from the air and the control tower.

Social Events

While the excellence of the technical sessions is the main course of a successful conference, well-planned social events can well be the "dessert" which rounds out the enjoyment of the meeting. Delegates to the Midwestern Regional Conference relaxed their concentration on technical subjects at a cocktail party given by courtesy of the Milwaukee electrical industries, and a buffet supper and entertainment by courtesy of the Blatz Brewing Co. in their famous Hospitality Room.



Personalities seen at the Midwestern Regional Conference May 17-19, Milwaukee, Wisconsin. In picture at left, in the usual order, I. L. Illing, Chairman of the Conference, and G. K. Hardacre, Past-President of I.E.S. At right is J. M. Ketch and Warren Edman.

Midwestern Regional Conference delegates enjoy Milwaukee's hospitality at the famous Blatz Hospitality Room.

COMMITTEE PERSONNEL

The committee members planning and conducting this successful Conference were:

Executive Committee: Ed. H. Grieb, Chairman, I. L. Illing, H. F. Ilgner, R. R. Knoerr and C. N. Laupp.
Conference Committee: I. L. Illing, Gen. Conference Chairman, H. F. Ilgner, Gen. Conference Vice-Chairman.
Papers and Program: C. N. Laupp, Chairman.
Publicity: J. H. Wanska, Chairman.
Finance: T. H. Markworth, Chairman.
Hotel and Arrangements: E. H. Schaefer, Chairman, Wm. Lisch.
Reception and Registration: R. R. Knoerr, Chairman, John Petersen.
Entertainment: E. H. Aik, Chairman.
Attendance: H. Grosh, Chairman, E. H. Aik, A. J. Von Burg, Chas. Lageman, G. M. Kammerer, L. C. Larson.
Social Fund Committee: T. H. Markworth, Chairman, E. H. Grieb, C. N. Laupp.

Special acknowledgment is also made to the chairmen of the following chapters for taking part in making the conference a success:

Gordon Fowler.....Chicago Section
H. W. Larson.....Cornhusker Chapter
H. R. Weibel.....Heart of America Section
Ross Brown.....Indiana Chapter
C. O. Christensen.....Iowa Section
Ed. H. Grieb.....Milwaukee Chapter
Melton Jones.....St. Louis Section
Robert Hamilton.....Twin City Section

Philadelphia Section Host to East Central Regional Conference

New and worthy ideas have a way of turning up at East Central Regional Conferences. The contest for "My Most Interesting Job" for instance, was initiated at last year's East Central Conference, repeated at this one, and carried on with success in other regions of I.E.S.

An innovation at the 1950 East Central Regional Conference, held at the Warwick Hotel, Philadelphia, May 18 and 19, was a full session of Questions with a distinguished panel of experts for the Answers. Billed as a "Get It Off Your Chest" session, the quiz type program was excellently organized, and proved a lively and stimulating feature. Organization included printed cards passed out to all delegates the minute they registered, to capture those "I should have asked so and so" questions which occur at off moments. Daily reminders and a certain amount of suspense were built up for this part of the program by Paul Hildebrand of the Eastern Pennsylvania Chapter, who did everything and including literally getting everything "off his chest" to stimulate participation.

Panel experts at the session were: A. A. Brainerd, for application questions. Willard Brown—sources expert. C. H. Goddard—Society questions. B. F. Greene—cold cathode specialist. Dean B. Judd—color expert. J. S. Schuchert—utility questions. D. P. Caverly—lamps. Fred Pyle—luminaires. G. J. Taylor—luminaires and industrial lighting.

Though popular in nature, this session was by no means a light-hearted affair. Discussions of considerable import developed from many of the questions.

MOST INTERESTING JOB CONTEST

With a previous year's experience behind them in this type of program, the East Central Region's "My Most Interesting Job" contest moved forward with professional precision. One contestant (Eastern Pennsylvania's representative) teamed up with a colleague, to present his entry in the form of a skit. He was represented as telling a visitor to his office, of the job he did. Huge colored slides of the job as it progressed, flashing up on a darkened part of the stage, dramatized his dialogue most effectively.

Winner of the contest was D. M. Hoffman of the Philadelphia Section, who featured the evolution of almost 100 years of lighting improvements in Pagel's Shoe Store, Philadelphia. Mr. Hoffman had drawings and actual photographs of the area, going back to 1879, showing each modernization from kerosene lamps, gas mantles, electricity (at the turn of the century), early fluorescent, and finally his prize-winning transformation of the store with planned lighting and integrated architectural feature. Mr. Hoffman's installation will be shown in an early issue of ILLUMINATING ENGINEERING.

Runners up in the contest were: H. M. White, representing the Baltimore Chapter, who presented a small department store, with lighting designed to contrast effectively with neighboring installations. A diamond-pattern module arrangement was an effective feature.

R. P. Teele, of the Capital Section, described the difficulties of overcoming the lighting problems peculiar to the Traffic Control Room of the Washington National Airport, where tension is high and the slightest glare a serious distraction.

E. W. Halteman, of Eastern Pennsylvania Chapter, presented the lighting of the "Stadium at Greenwood, Pa." a large roller skating rink. Assisted by Russell Stuart of the Metropolitan Edison Co., Mr. Halteman presented his entry in the skit described above.

John E. Emory of the Pittsburgh Section, described, and demonstrated with slides, the planned lighting he had developed for the offices and warehouses of his own company, Graybar Electric, in Pittsburgh.

"LIGHT UP TOMORROW"

The first "road show" of the dramatic presentation of how to organize and get a Planned Lighting program underway—which had its successful opening at the E.E.I. conference in Chicago—was a feature of the East Central Region's program. Many of the opening stars were still in the cast of the Philadelphia showing. Even a dramatic critic would rate this show as good. Judging from the Philadelphia audience, lighting people are delighted with it. The all star cast of "Light Up Tomorrow" included:

Narrator—Joseph P. Hollenbach, Phila. Electric Co.

Hal Skinner—Leo E. Duval, Sylvania Electric Products, Inc.

I.E.S. President C. H. Goddard (left) is welcomed to the East Central Regional Conference in Philadelphia, May 18-19, by A. S. Raffel (center), electrical contractor of Baltimore, and Chairman (1949-50) of the Baltimore Chapter. Fred Pyle, Conference Chairman, looks on. ***Photo courtesy of Berlon C. Cooper, Electrical Construction and Maintenance.***

Peggy Murphy—Jan Reynolds, Sylvania Elec. Prods., Inc.

Frank Turner—Charles I. Schneider, Electro Manufacturing Co.

Charles Bennett—Peter T. Lagrone, Westinghouse Elec. Corp.

The "Boss"—Harry A. Crossdale, Westinghouse Elec. Corp.

Hector Hush—James R. Duffy, Sylvania Elec. Prods., Inc.

Ramond—Steve Sacklarian, Phila. Electric Co. Model—Rose Anita Schubert, Philadelphia Electric Co.

Mr. Lewis—Frank R. Innes, Electrical World
Mrs. Smythe-Smythe—Lucy Long, McCall's Magazine.

Supt. of Schools—Perc P. Thorne, General Electric Co.

Mr. Jones—Engle Taylor, Phila. Electric Co.

Mrs. Jones—Kathryn Goodall, Phila. Electric Co.

Director—Harold H. Greene, General Electric Company.

Stage Crew—C. C. Shotwell, Phila. Elec. Co.; P. B. Thorne, General Electric Co.; J. F. Lowrey, Phila. Elec. Co.; Paul Kyack, Bond & Kyack; J. H. Rich, Phila. Elec. Co.; and T. H. Murray, W. A. Leiser Co.

President's Banquet

The banquet honoring President and Mrs. Goddard on Wednesday evening was highlighted by addresses by President Goddard, and Father Thomas Burke of Villanova College, main speakers.

An additional speaker at the banquet, not previously announced, was a distinguished gentleman introduced as "Dr. Kilgare." He held the audience spellbound with a talk on atomic energy. After some ten minutes of absorbed interest, it dawned on the company that the humorous stories punctuating "Dr. Kilgare's" address were assuming a pattern. Dr. Kilgare was a professional entertainer, with a vast repertoire of wonderful stories, punch lines of which were being jotted down all over the room.

Technical Program

The East Central Regional Conference was planned to be of value to a variety of interests, with technical aspects foremost. The Thursday afternoon session was devoted entirely to the presentation of three excellent papers on color, luminous ceilings and television studio lighting. (See program below.)

Keynote address to the 178 delegates was made by George E. Whitwell, Vice-President of the Philadelphia Electric Co., in whose office the Better Light-Better Sight slogan was born. Mr. Whitwell gave a very enlightening and thought-provoking address on the nationalization of electric power in America, showing with slides the immense growth of this trend.

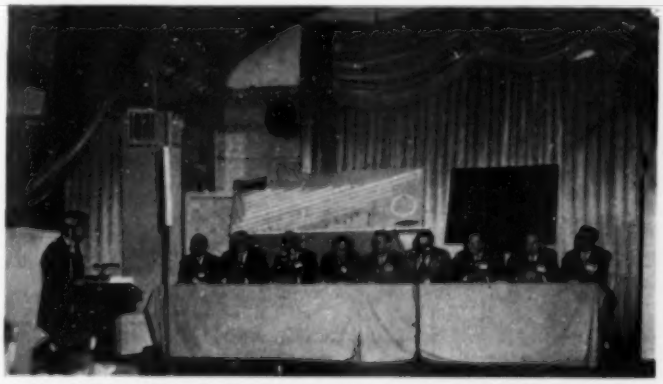
J. S. Schuchert, East Central Regional Vice-President, welcomed the delegates to the conference in an address on the value of such conferences to the Region's members. He described Regional Conferences as branches of National Conferences — to compare present practices with the past and plan for the future. He stressed the value to engineers, scientists, of the I.E.S. pooling of knowledge, and pointed out the benefit of I.E.S. work and I.E.S. Conferences to all branches of the lighting industry. The program, in detail, included:

Morning Session
Thursday, May 18, 1950

Opening Session—*Chairman*, W. R. Robison, Chairman, Eastern Pennsylvania Chapter.
1. Address of Welcome—J. S. Schuchert, Regional Vice-President, East Central Region.
2. Keynote Address — George E. Whitwell, Vice-President, Philadelphia Electric Company.
3. Presentation of Planned Lighting Skit—"Light Up Tomorrow," Better Light-Better Sight Bureau.
4. 12:30 P.M. Luncheon Meeting—Chairman, Jos. Schuchert, Speaker: Charles H. Goddard, President, I.E.S.

Afternoon Session
Chairman, A. S. Raffel
Chairman, Baltimore Chapter

5. Color and Its Measurements—Dr. D. B. Judd, National Bureau of Standards.
6. Lighting from Louverall Ceilings and Other Large Area Luminous Surfaces—Don P. Caverly and Rold. Wylie, Sylvania Electric Products Inc.
7. Lighting for Television—R. L. Zahour, Westinghouse Electric Corp.



"Get It Off Your Chest" session at the East Central Regional Conference featured a panel of experts from all fields. Pondering delegates' questions are, left to right: Paul Hildebrand (at rostrum), narrator. A. A. Brainerd, C. H. Goddard, Willard Brown, B. F. Greene, D. B. Judd, J. S. Schuchert, Fred Pyle, D. P. Caverly, and G. J. Taylor. ***Photo courtesy of Berlon C. Cooper, Electrical Construction and Maintenance.***

Contestants for "My Most Interesting Job" award at the East Central Regional Conference. George S. Clarke (left) is shown with the five contestants—left to right: H. M. White, Baltimore Chapter, E. W. Halteman, Eastern Pa. Chapter, John Emory, Pittsburgh Section, D. M. Hoffman, Philadelphia Section (the winner), and R. P. Teele, Capital Section. ***Photo courtesy of Berlon C. Cooper, Electrical Construction and Maintenance.***

EVENING SESSION

7:00 P.M. — BANQUET

Toastmaster, F. M. Pyle

Chairman, Philadelphia Section

Lighting Education—Father Thomas Burke, Villanova College.

MORNING SESSION, MAY 19, 1950

Chairman, Alex. Hampsey

Chairman, Pittsburgh Section

8. Recent Developments in Light Sources—Willard C. Brown, Managing Engineer, General Electric Co.

9. Open Forum Discussion—Led by Paul M. Hildebrand.

AFTERNOON SESSION

"My Most Interesting Lighting Job"—Chairman, J. P. Bachman, Chairman, Capital Section.

a. Baltimore Chapter.
b. Capital Section—R. P. Teele.
c. Eastern Pa. Chapter—E. W. Halteman.
d. Philadelphia Section—D. M. Hoffman.
e. Pittsburgh Section—John E. Emery.

COMMITTEE PERSONNEL

The Regional Conference Committee planning East Central's successful meeting were:

Chairman	F. M. Pyle
Vice-Chairman	C. C. Shotwell
Program	A. A. Brainerd
Finance and Registration	F. R. Adair
Attendance and Reception	J. F. Roberts
Ladies' Entertainment	A. S. Turner
Hotel	R. S. Bucher
Property	M. N. Flynn
Publicity	R. D. Maynard

Great Lakes Regional Conference Features Fine Technical Program

An outstanding program of excellent papers highlighted the Great Lakes Regional Conference held May 22-23 in Buffalo, N. Y., as one of the Region's most successful meetings. Technical subjects of practical interest to lighting practitioners were presented by a number of leading specialists at the packed sessions.

Some 150 delegates registered for the Conference, at the Hotel, Buffalo.

Under the General Chairmanship of William B. Campbell, Buffalo Niagara Electric Corp., the Conference opened early on Monday morning with address by C. H. Goddard, President of I.E.S., W. A. Stannard, Great Lakes Regional Vice-President, and C. L. Crouch, the Society's Technical Director.

"MY MOST INTERESTING JOB"

A feature of the Monday morning session was the judging of four entries in the regional contest for "My Most Interesting Lighting Installation."

Judges C. H. Goddard, C. L. Crouch, H. M. Sharp and W. A. Stannard awarded first prize to Alfred Sangster, the Michigan Section's entry for his excellent presentation of a church window lighting job.

Other entries, representing winners of intra-Section contests held prior to the Conference, were: Merle E. Keck, Cleveland Section—lighting for a Kentucky race track. T. S. Harmon, Central New York Chapter—lighting an air terminal. J. F. B. Parsons, Western New York Section—low brightness cold cathode office lighting.

TECHNICAL PROGRAM

Starting with the afternoon session on Monday, which was under the direction of Arthur P. Hammerstein as Chairman, the technical program included:

"Noma and I.E.S. Sports Lighting Standards," by Albert H. Clarke, Crouse-Hinds Co.

"The Key to Good Sports Lighting," by Merle E. Keck, Westinghouse Electric Corp.—Covering proper analysis and calculations of illuminations for sports fields.

"The Color Calibrator," by Granville Breinig, Pratt & Lambert Co.

"Loss of Visibility Due to Reflected Glare," by Howard M. Sharp, Consulting Engineer, and J. F. Parsons, Niagara Mohawk Power Corp.—An analysis of reflected sheen from nine different printing papers together with various inks. One of the practical conclusions derived from the study was the fact that 30 footcandles of illumination from a large area low brightness system was equal to 50 footcandles of direct fluorescent lighting, with an apparent waste of 20 footcandles.

"The Macy Report—A Field Study of Brightness Out of Control," by George P. Wakefield, F. W. Wakefield Brass Co.

"TV Studio Lighting," by R. L. Zahour, Westinghouse Electric Corp., and H. M. Gurin, National Broadcasting Co.

TUESDAY, MAY 23

MORNING SESSION

R. W. Brown, *Chairman*

"School Lighting Economics," by George Seiter, Cincinnati Gas & Electric Co.

"High Speed Recorder for Appraising Street Lighting Systems," by A. H. Taylor and W. G. Pracejus, General Electric Co.—Description of a system for obtaining illumination values from a rapidly moving vehicle.

"Fluorescent Street Lighting Study," by Harold Wall, Detroit Public Lighting Commission.

"Church Lighting Technique," by Harold H. Fisher, Architect, Detroit, Michigan.

"Modern Lighting for Libraries," by James M. Ketch, General Electric Co.

AFTERNOON SESSION

C. L. Amick, *Chairman*

"Discoloration of Meats When Exposed to High Level Illumination," by Hugh M. Archer and R. E. Bandfield, Detroit Edison Co.

"The Practical Use of the Luckiesh-Moss Visibility Meter," by Arthur A. Eastman, General Electric Co.

"Chalkboard Visibility Study," by W. H. Kahler, Westinghouse Electric Corp.—Results of an analysis of the visibility of chalkboard writing tasks with various reflectances of the board and the chalk used.

"Modular Lighting," by Robert W. Wylie, Sylvania Electric Products Inc.

"Colored Lighting for Color Printing," by E. A. Lindsay, General Electric Co.—Showing the use of filters with fluorescent lamps to produce the proper color mix in color printing.

LADIES' PROGRAM

The Great Lakes Regional Conferences have traditionally attracted a number of visiting ladies, this one being no excep-

tion. The many ladies attending the Buffalo meeting enjoyed a program organized for them by Winifred C. Erdle.

Among other entertainment features, they enjoyed an automobile tour with lunch at Niagara Falls, joined the men for the President's Reception and Dinner Dance, Monday evening, and participated in a breakfast radio program at Laube's Old Spain.

COMMITTEES

Successful Regional programs entail much work, as many I.E.S. members know. Those directing the Great Lakes meeting were:

William B. Campbell, Buffalo Niagara Electric Corp., General Chairman.

J. F. Parsons, Niagara Mohawk Power Co., Secretary-Treasurer.

E. W. Fowler, Buffalo Niagara Electric Corp., Papers.

John F. Buckley, General Electric Co., Publicity.

Francis P. Burke, Ferguson Electric Construction Co., Registration.

Addison K. Parsons, Westinghouse Electric Corp., Hotel.

Henry W. Osborne, Traffic Engineer, City of Buffalo, Entertainment.

Winifred C. Erdle, Beman & Candee, Ladies Committee.

Milton Milstein, Architect, Decorations.

Raymond P. Conners, Sylvania Electric Products Inc., Local Attendance.

No photographs were taken at this Conference, which was purely technical in nature.

Election of New I.E.S. Officers

At a meeting of the Council held June 8, 1950, the report of the Committee of Tellers was presented, giving the results of the recent election of officers for the coming year, beginning October 1, 1950. The following have been elected to the offices indicated:

GENERAL OFFICERS

President—Walter Sturrock, General Electric Co., Nela Park, Cleveland, Ohio.

Vice-Presidents—Samuel G. Hibben, Westinghouse Electric Corp., Bloomfield, N. J.; Everett M. Strong, Cornell University, Ithaca, N. Y.

General Secretary—A. Homer Manwaring, Philadelphia Elec. & Mfg. Co., Philadelphia, Pa.

Treasurer—R. F. Hartenstein, Ohio Edison Co., Akron, Ohio.

Directors (until 1951)—Myrtle Fahsbender, Westinghouse Electric Corp., Bloomfield, N. J. and Hoyt P. Steele, Benjamin Electric Mfg. Co., Des Plaines, Ill.; (until 1952)—Rudolph E. Biesele, Jr., 3241 Amherst St., Dallas, Texas and Duncan M. Jones, Curtis Lighting Co. of Canada Ltd., 19 Ballantyne Ave. N., Montreal, Que., Canada; (until 1953)—Roy A. Palmer, Duke Power Co., Power Bldg., Charlotte, N. C. and L. A. Hobbs, Smoot-Holman Co., P. O. Box 398, Inglewood, Calif.

Regional Vice-Presidents—Canadian Region—George F. Dean, Toronto Hydro-Electric System, Toronto, Ont., Canada; East Central Region—Joseph S. Schuchert, Duquesne Light Co., Pittsburgh, Pa.; Great Lakes Region—F. C. Winkler, Westinghouse Electric Corp., Cleveland, Ohio; Midwestern Region—Charles N. Laupp, 7633 N. Boyd Way, Milwaukee, Wisc.; Northeastern Region—R. G. Slauer, Sylvania Electric Products Inc., Salem, Mass.; Pacific Northwest Region—K. E. Hollingsworth, Puget Sound Power & Light Co., Seattle, Wash.; Southern Region—Joe B. Browder, Georgia Power Co., Atlanta, Ga.; South Pacific Coast Region—C. O. Martin, Benjamin Electric Mfg. Co., San Francisco, Calif.; Southwestern Region—Floyd A. Covington, Box 1771, San Antonio, Texas.

BRITISH COLUMBIA SECTION

Chairman—S. C. Smith, Canadian Westinghouse Co. Ltd., Marine Bldg., Vancouver, B. C., Canada. *Secretary*—K. Merritt, 4326 W. 8th Ave., Vancouver, B. C., Canada. *Board of Managers*—R. M. Campbell, C. A. Morrison, R. Racine, R. G. Scott, E. W. Thompson.

CAPITAL SECTION

Chairman—George W. Clark, Sylvania Electric Products Inc., Alexandria, Va. *Vice-Chairman*—Ray P. Teele, 3713 Jenifer St., N.W., Washington, D. C. *Secretary*—H. Marshall Dixon, Jr., 1203 W. Braddock Rd., Alexandria, Va. *Board of Managers*—Joseph P. Bachman, Jr., Horace L. Guiney, Dorothy Nickerson, Frank S. Walters.

CHICAGO SECTION

Chairman—C. B. Pederson, Illinois Bell Telephone Co., Chicago, Ill. *Vice-Chairman*—R. R. Lusk, Commonwealth Edison Co., Chicago, Ill. *Secretary*—W. A. Weibel, Curtis Lighting Inc., Chicago, Ill. *Board of Managers*—O. G. Boyd, W. F. Carson, C. F. Jensen, E. M. Stein.

CLEVELAND SECTION

Chairman—F. E. Mueller, 1296 Nicholson, Lakewood, Ohio. *Secretary*—G. K. Warner, Day-Brite Lighting Inc., Cleveland, Ohio. *Board of Managers*—A. C. Barr, R. I. Bull, H. E. Carney, R. N. Green, J. J. Neidhart.

CONNECTICUT SECTION

Chairman—R. M. Hendricks, The So. New England Telephone Co., New Haven, Conn. *Vice-Chairman*—C. W. McCormick, Connecticut Light and Power Co., Waterbury, Conn. *Secretary*—Francis Clark, Rm. 45, 63 Bank St., Waterbury, Conn. *Board of Managers*—E. R. Cole, V. J. Ouellette, W. N. Warnes, L. T. Wilcox.

GEORGIA SECTION

Chairman—Harold M. Horton, General Electric Co., Atlanta, Ga. *Vice-Chairman*—T. Taylor Peake, 725 E. Morningside Dr., N. E., Atlanta, Ga. *Secretary*—R. H. Hiller, Curtis Lighting Inc., Atlanta, Ga. *Board of Managers*—L. Ralph Bush, Judd Lough, Jack H. Murrah, O. V. Scott.

HEART OF AMERICA SECTION

Chairman—John M. Weir, W. T. Toley Electric Co., Kansas City, Kan. *Vice-Chairman*—Ray E. Perry, Kansas City Power & Light Co., Kansas City, Mo. *Secretary*—F. I. Feagans, Kansas City Power & Light Co., Kansas City, Mo. *Board of Managers*—Benjamin F. Cook, Robert S. Everitt, Frederick H. Heintz, J. M. Lime.

IOWA SECTION

Chairman—W. Dean Barnhiser, Iowa Electric Light & Power Co., Cedar Rapids, Iowa. *Vice-Chairman*—Chester P. Stone, Blackhawk Electric Co., Waterloo, Iowa. *Secretary*—Herbert P. Wilson, Electrical Institute of the Tri Cities, Rock Island, Ill. *Board of Managers*—C. O. Christensen, J. C. Gehan, A. E. Johnson, W. T. Reace, Jr.

MICHIGAN SECTION

Chairman—Ivar H. Stockel, P.O. Box 125, Roosevelt Park Annex, Detroit, Mich. *Secretary*—Alfred C. Sangster, 10961 Nottingham, Detroit, Mich. *Board of Managers*—John E. Dawson, Leslie D. Lyons, Harry M. Macfarlane, John T. Parks, John C. Ringland.

MONTREAL SECTION

Chairman—Frank P. Labey, Northern Electric Co. Ltd., Montreal, Que., Canada. *Secretary*—Kenneth R. Jeffrey, Amalgamated Electric Corp. Ltd., Montreal, Que., Canada. *Board*

LIGHTING CALENDAR

Society Events

August 21-24, 1950 — Southern California National Technical Conference, Hotel Huntington, Pasadena, Calif.

October 12, 1950—Meeting of I.E.S. National Council, New York, N. Y.

October 26-27, 1950—Northeastern Regional Conference, Hotel Statler, New York, N. Y.

March 4-6, 1951 — Southwestern Regional Conference, Corpus Christi, Texas.

March 12-16, 1951—South Pacific Regional Conference, San Francisco, Calif.

March 19-24, 1951—Pacific Northwest Regional Conference, Spokane, Wash.

April 9-10, 1951—Southern Regional Conference, Miami, Fla.

May 9-12, 1951—Canadian Regional Conference, Chateau Frontenac, Quebec.

May 14, 1951—Midwestern Regional Conference (Hotel and City not yet announced).

May 21, 1951—Great Lakes Regional Conference, Cincinnati, Ohio.

Industry Events

July 1-8, 1950—N. Y. State Association of Electrical Contractors & Dealers Inc., Annual Convention, Saranac Inn, N. Y.

August 7-19, 1950 — First United States International Trade Fair, Chicago, Ill.

September 18-21, 1950 — International Municipal Signal Association, 55th Annual Convention, Hotel Commodore, New York, N. Y.

September 19-21, 1950 — The American Society of Mechanical Engineers, Fall Meeting, Hotel Sheraton, Worcester, Mass.

September 25-27, 1950—National Electronics Conference, Chicago, Ill.

September 27-29, 1950 — *Sixth annual* meeting, Canadian Electrical Manufacturers Association, General Brock Hotel, Niagara Falls, Canada.

October 11-14, 1950 — International Association of Electrical Leagues, 15th Annual Conference, Copley Plaza, Boston, Mass.

October 11-14, 1950 — The Electrochemical Society Inc., 98th Meeting, Statler Hotel, Buffalo, N. Y.

October 16-20, 1950 — 38th National Safety Congress & Exposition of the National Safety Council, Chicago, Ill.

October 17-20, 1950 — National Electrical Contractors Association, Annual Convention, Hotel Biltmore, Los Angeles, Calif.

October 23-27, 1950 — American Institute for Electrical Engineers, Fall General Meeting, Skirvin Hotel, Oklahoma City, Okla.

November 13-16, 1950 — National Electrical Manufacturers Association, Chalfonte-Haddon Hall, Atlantic City, N. J.

November 26 - December 1, 1950 — The American Society of Mechanical Engineers, Annual Meeting, Hotel Statler, New York, N. Y.

November 27-29, 1950 — American Standards Association, Annual Meeting, Waldorf-Astoria Hotel, New York, N. Y.

December 3-8, 1950 — The American Society of Refrigerating Engineers, 46th Annual Meeting, Hotel Commodore, New York, N. Y.

of Managers—Roy A. Eckeley, Ralph E. Hendershot, Robert S. Tate, William L. Vincent, Leonard Weightman.

NEW ENGLAND SECTION

Chairman—John W. Young, New England Power Service Co., Boston, Mass. *Secretary*—Norman E. Ticehurst, Cambridge Electric Light Co., Cambridge, Mass. *Board of Managers*—Fred D. Crowther, Cornelius J. Kelleher, Frederick J. Lawson, Kenneth A. Sawin, Ralph H. Spaulding.

NEW ORLEANS SECTION

Chairman—B. Z. Segall, Best Electric Co., Inc., New Orleans, La. *Vice-Chairman*—R. C. Pasley, Louisiana Power & Light Co., New Orleans, La. *Secretary*—Harry T. Bailey, Jr., Louisiana Power & Light Co., Gretna, La. *Board of Managers*—J. M. Gensburger, E. C. Guillot, Jr., J. F. Morton, B. E. M. Sherrett, Jr.

NEW YORK SECTION

Chairman—Carroll L. O'Shea, General Electric Co., New York, N. Y. *Vice-Chairman*—Marshall S. Waterman, Westinghouse Electric Corp., Bloomfield, N. J. *Secretary*—Ernest H. Salter, 102 Cleveland Ave., Great Kills, S. I., N. Y. *Board of Managers*—Emil W. Lampert, Charles A. Lehman, Harris Reinhardt, Alex Sitkin.

NORTHERN CALIFORNIA SECTION

Chairman—Sol Cohn, California Electric Supply Co., San Francisco, Calif. *Vice-Chairman*—Stanton M. Blacksmith, 5635 Colton Blvd., Oakland, Calif. *Secretary*—Robert W. Thunen, Sylvania Electric Products Inc., San Francisco, Calif. *Board of Managers*—Arthur Anderberg, Dan M. Finch, Samuel H. Hazleton, Jr., William R. Major, Jr.

OHIO VALLEY SECTION

Chairman—Robert W. Brown, Cincinnati Gas & Electric Co., Cincinnati, Ohio. *Vice-Chairman*—J. F. Voelker, 2650 Cedarbrook Dr., Cincinnati, Ohio. *Secretary*—R. J. Schulte, General Electric Co., Cincinnati, Ohio. *Board of Managers*—Donald G. Berthe, H. K. Flint, James R. Fuller, William A. Gale.

OREGON SECTION

Chairman—J. G. Galarneau, Packard-Malloy, Inc., Portland, Ore. *Vice-Chairman*—E. R. Fletcher, Portland General Electric Co., Portland, Ore. *Secretary*—Frank M. Reis, Pacific Power & Light Co., Portland, Ore. *Board of Managers*—Richard Feinberg, Cyril D. Ham, C. H. Lundell, J. Daniel Webster.

PHILADELPHIA SECTION

Chairman—Conrad F. Bond, 7804 Linden Rd., Philadelphia, Pa. *Vice-Chairman*—Percy B. Thorne, General Electric Co., Philadelphia, Pa. *Secretary*—R. M. Hest, Philadelphia Electric Co., Philadelphia, Pa. *Board of Managers*—F. R. Adair, Maxwell Cole, Sylvan W. Drucker, T. W. Lauer.

PITTSBURGH SECTION

Chairman—Corydon M. Cryster, General Electric Co., Pittsburgh, Pa. *Vice-Chairman*—Nelson C. Warner, Westinghouse Electric Corp., Pittsburgh, Pa. *Secretary*—Gordon H. Maise, Duquesne Light Co., Pittsburgh, Pa. *Board of Managers*—Alex R. Hampsey, Jr., Henry J. Masur, John B. Rhea, Byron W. Townsend.

PUGET SOUND SECTION

Chairman—H. A. Gardner, 4173 42nd N. E., Seattle, Wash. *Secretary*—Clarence A. Scheyer, Puget Sound Power & Light Co., Seattle, Wash. *Board of Managers*—Robert V. Bardsley, Frederick E. Cooper, Paul Davis, Henry B. Huber, Byron G. Lind.

ROCKY MOUNTAIN SECTION

Chairman—H. T. Rankin, Pub. Ser. Co. of Colorado, Denver. *Vice-Chairman*—G. B. Buck, II, General Elec. Co., Denver. *Sec.-Treas.*—F. Bischofberger, Public Ser. Co of Colo., Denver. *Board of Managers*—Howard Ernst, James L. Bannenan, Glen Gale, A. F. Weers.

ST. LOUIS SECTION

Chairman—William H. Simms, Union Electric Co. of Missouri, St. Louis, Mo. *Secretary*—J. J. Rhoades, City Sales, Inc., St. Louis, Mo. *Board of Managers*—Henry Arenden, E. L. Ehret, T. P. Gleeson, Melton Johns, Carter Lewis.

SOUTHERN CALIFORNIA SECTION

Chairman—W. A. McGuire, 1330 N. Keystone St., Burbank, Calif. *Secretary*—Roy E. Dahlin, So. California Edison Co. Ltd., Los Angeles, Calif. *Board of Managers*—W. L. Friend, J. W. Howard, C. R. Long, Oscar W. Meissner, F. J. Rohring.

SOUTH TEXAS SECTION

Chairman—Warren W. Williamson, Tennessee Gas Transmission Co., Houston, Texas. *Vice-Chairman*—George S. Trotter, General Electric Co., Houston, Texas. *Secretary*—M. Davis Alexander, 3779 Odin Court, San Jacinto Garden Apts., Houston, Texas. *Board of Managers*—Harry Hrivnats, C. L. Jenkins, Thomas L. Moore, Norval O. Reed.

SOUTHWESTERN SECTION

Chairman—C. M. Cockrell, Jr., 2712 Live Oak, Dallas, Texas. *Vice-Chairman*—James T. Meletio, 316 S. Preston, Dallas, Texas. *Secretary*—W. T. Kimory, Dallas Power & Light Dome, O. W., Electric Supply & Equipment Co., Dallas, Texas. *Board of Managers*—R. L. Biesele, Jr., W. F. Folsom, H. O. Jones, W. H. McAdams.

TORONTO SECTION

Chairman—R. C. Allison, T. Eaton Co., Toronto, Ont., Canada. *Secretary*—K. L. Dodington, University of Toronto, Toronto, Ont., Canada. *Board of Managers*—F. E. Barker, J. A. I. Kidd, Joseph E. Landers, Wilfred F. C. Nottelman, Bertram A. Wilson.

TWIN CITY SECTION

Chairman—A. E. Hallaway, 6101 France Ave. S., Minneapolis, Minn. *Secretary*—L. J. Biegert, Branham Mareck & Duepner, Inc., Minneapolis, Minn. *Board of Managers*—B. William Frederick, Donald P. Greene, R. H. Hamilton, E. J. Stephens, F. T. Tillemans.

WESTERN NEW YORK SECTION

Chairman—William B. Campbell, Buffalo Niagara Electric Corp., Buffalo, N. Y. *Vice-Chairman*—William A. Biser, General Electric Co., Buffalo, N. Y. *Secretary*—George Reinagel, Reinagel Lighting Co., Buffalo, N. Y. *Board of Managers*—Edwin S. Burrows, Raymond P. Connors, Winifred C. Erdle, E. W. Fowler.

NEW MEMBERS

At the meeting of the Council held June 8, 1950 at the Hotel Roosevelt, New York, the following were elected to membership:

BALTIMORE CHAPTER

Associate Members:

Brody, S. H., H. A. Harris Co., Towson, Md.
Gladstein, N. W., Excello Public Service Corp.
McNeill, R. E., Henry Adams, Inc.

BRITISH COLUMBIA SECTION

Associate Member:

Morrison, J. H., A. E. Simpson, Consulting Electrical Engineer, 455 Richards St., Vancouver

Student Members:

Elson, J. W., University of British Columbia, Vancouver
Kolbeins, E. N., University of British Columbia, Vancouver

CAROLINAS CHAPTER

Associate Members:

Co., Greensboro, N. C.
Fishburne, E. W., Litecontrol Corp., Greensboro, N. C.
Green, E. T., Talley Electric Co., Greensboro, N. C.
Locke, J. W., General Electrical Supply Corp., Charlotte, N. C.
McKinney, W. R., Westinghouse Electric Corp., Charlotte, N. C.
Moore, G. M., Watson & Hart, Greensboro, N. C.
Patterson, D. D., Patterson Electric Co., Greensboro, N. C.
Penn, F. R., Reidsville Engineering Co., Inc., Reidsville, N. C.
Simon, W. R., Love Electric Co., Greensboro, N. C.
Talley, C. H., Talley Electric Co., Greensboro, N. C.

CLEVELAND SECTION

Member Emeritus:

Luckiesh, Matthew, Dr., 21175 Shaker Blvd., Shaker Heights 22, Ohio

Member:

Daykin, H. R., The Bostwick Braun Co., Toledo

Associate Members:

Bauman, H. M., Bauman Electric Service, Bluffton, Ohio
Gerengher, J., A. G. McKee Co., Cleveland

Student Member:

Gibson, N. S., Case Institute of Technology, Cleveland

CONNECTICUT SECTION

Associate Members:

DeFelice, F. C., Hill & Harrigan, New Haven
Kline, H. C., Dr., Optometrist, 152 Temple St., New Haven

EASTERN PENNSYLVANIA CHAPTER

Associate Members:

Keefer, W. R., Neon Sign Service, Littlestown, Pa.
Orben, K. E., Penn. Power & Light Co., Bethlehem, Pa.
Parks, G. E., Metropolitan Edison Co., Reading, Pa.
Reber, J. V., Metropolitan Edison Co., Reading, Pa.

FOREIGN NON-SECTION

Member Emeritus:

Maisonneuve, Henry, 217 rue de l'Universite, Paris, France

Continued on page 16A

New, Easy Way to Get All I.E.S. Technical Reports

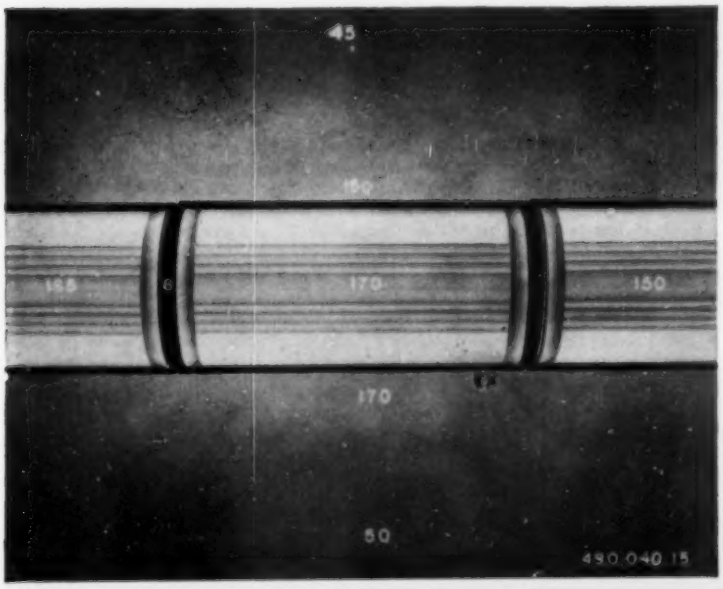
Each year technical committees of the I.E.S. prepare for publication their reports on important findings on various phases of lighting and new recommended lighting practices. Since many members of the Society have use for every one of these reports in booklet form as soon as they are published, it has been authorized that a "report subscriber" system be set up in the Publications Office so that these members automatically receive a copy of each booklet immediately upon publication. Included would be technical reports such as "Recommended Practice of Daylighting," "Lighting for Canneries," "Lighting for Flour Mills," and others. "Report subscribers" will be billed with each report as they receive it.

I.E.S. members who desire to have a complete set of technical committee reports during each year will find this an ideal plan for keeping their lighting libraries up to date. Requests for this service should be addressed directly to Publications Office, Illuminating Engineering Society, 51 Madison Ave., New York 10, N. Y.

How To Create A Modern Office

conforming to I. E. S. Recommended Practice of Office Lighting

How an office was designed, decorated and lighted to achieve reflectances, brightnesses and brightness ratios meeting or bettering (except in one instance: the reflectance of the floor covering is too low) all requirements of I.E.S. Recommended Practice of Office Lighting is told in detail in this 8 Page Engineering Survey by an independent consulting illuminating engineer. Write for your copy to THE F. W. WAKEFIELD BRASS COMPANY, VERMILION, OHIO.



ANOTHER WAKEFIELD STAR INSTALLATION

The office described in the Engineering Survey is lighted by 4 continuous rows of Wakefield STARS, each luminaire containing four 4500° white slimline fluorescent lamps 72 inches long. Taken from the Survey is this view looking vertically upward from underneath a luminaire. The Survey says: "This is the brightness pattern that would be reflected by a glossy desk top located under the luminaire. The low brightnesses and brightness ratios found here prove that reflected glare is not a problem in this office." The STAR has a luminous, indirect plastic reflector which slides in and out like a drawer.

Wakefield Over-ALL Lighting

A BASIC OFFICE TOOL

in a fluorescent BALLAST?

Do you want long — trouble-free service? . . .

CERTIFIED ETL SPEC NO 6

When it's a SOLA "Sequenstart" BALLAST

. . . just install and forget it!

SOLA Sequenstart Ballasts are engineered on a new SOLA principle that delivers peak performance continuously. Compare the following points of superiority right down the line with any ballast on the market. The SOLA "Sequenstart" are premium ballasts at moderate cost.

UL

SOLA "Sequenstart" Ballast compared with Ordinary Ballasts

- Up to 14% more light for the same power cost!
- Up to 52% less watts loss!
- Maintains constant light output with primary voltage range from 95-130 volts!
- Weighs up to 52% less than certain competitive models. Reduces fixture weight, cuts shipping costs and installation expense!
- Less heat rise externally and internally— By Resistance nearly 40% less — By Thermocouple up to 24% less. Reduces air conditioning costs and prolongs ballast life!
- Ventilated capacitor compartment is 42% cooler!
- Small size permits installation in standard slimline channels!

SOLA "sequenstart" Constant Wattage **BALLASTS**

20 YEARS ENGINEERING LEADERSHIP

Reliable Industry Rate Constant Voltage • Fluorescent Lighting • Cold Cathode Lighting • Airport Lighting • Series Lighting • Luminous Tube Signs • Sensor Ignition • X-Ray • Power • Controls • Digital Systems • etc. • SOLA ELECTRIC COMPANY, 4633 W. 16th Street, Chicago 50, Illinois

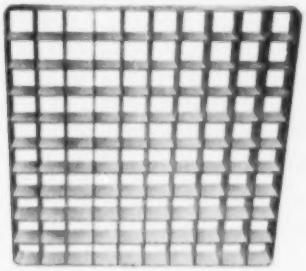
HOW TO UTILIZE THE SYLVANIA "FLEXI-MODULE" LIGHTING SYSTEM

PART 4

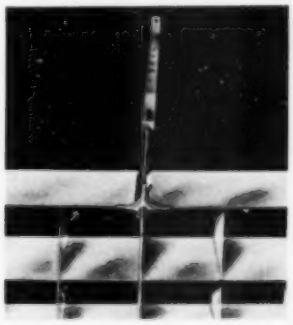
Easy to Install *and adjust*

Lighting engineers appreciate the efficiency and the remarkably easy installation of the Sylvania "Flexi-Module" Ceiling.

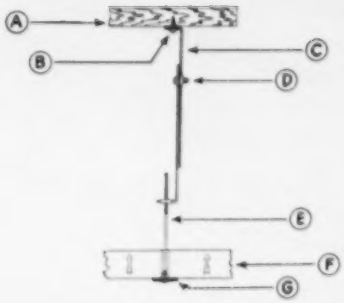
No rails or T-bars or other framing necessary. The 32-inch square module sections are made of sturdy, lightweight aluminum. Sections are quickly joined and secured at each corner by specially designed "Star" suspension units.



These improved units allow for both preliminary and final adjustments. The straps, when fully extended, place the louver bottom 36 inches below the point of support. Quickly adjusted to the nearest inch with binding speed-nuts inserted in pre-punched holes.



Final accurate adjustments are made from below by screwing up by hand threaded bolts in the "Star" supports. (See diagram at upper right.)



A. Upper ceiling or other overhead support.
B. Screw or bolt from supporting strap, depending upon type of installation.
C. Perforated metal strapping. Holes on 1½-inch centers for rough adjustments. Approximate maximum extended length 38 inches.
D. Positive binding speed-nuts.
E. 10-inch bolt, threaded 2½ inches for final adjustment of ceiling from below.
F. Grid sections of non-static, lacquer-finished aluminum. Lightweight and dust resistant.
G. "Star" support interlocks adjoining sections, but permits any one to be independently removed.

And remember, there are Sylvania Fluorescent Lighting Fixtures for every "Flexi-Module" installation, from the long, slim, instant-start, single lamp units to the dual-lamp reflectored units for concentrated down light at high levels.

Mail the coupon for complete information on the Sylvania "Flexi-Module" Lighting System.

Sylvania Electric Products Inc.
Advertising Dept. L-2907
1740 Broadway, New York 19, N. Y.

Please send me full information on the Sylvania "Flexi-Module" Lighting System.

*Name*_____

*Company*_____

*Street*_____

*City*_____ *Zone*____ *State*_____

SYLVANIA ELECTRIC

FLUORESCENT LAMPS, FIXTURES, SIGN TUBING, WIRING DEVICES; LIGHT BULBS; RADIO TUBES; TELEVISION PICTURE TUBES; ELECTRONIC PRODUCTS; ELECTRONIC TEST EQUIPMENT; PHOTOLAMPS; TELEVISION SETS

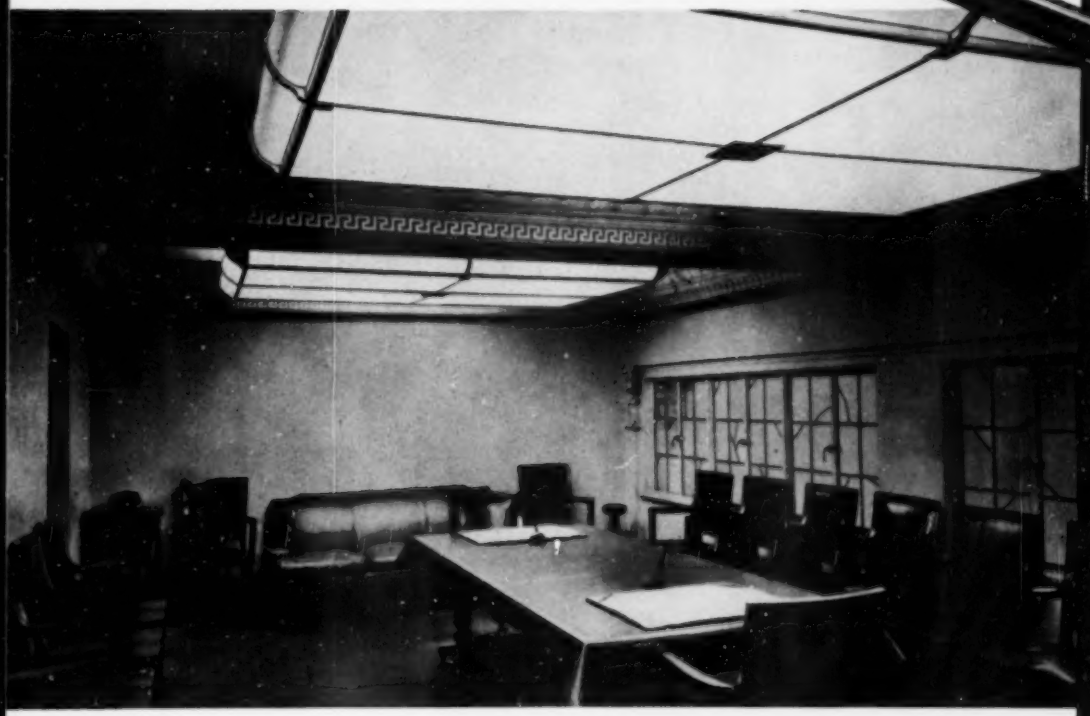
"the Board of Directors unanimously

No wonder PLEXIGLAS lighting wins approval. It provides glarefree, shadowless illumination wherever installed, from Directors' Rooms to housewives' kitchens. The full output of the lighting source is evenly diffused across the surface of this highly efficient acrylic plastic. Result: A luminous atmosphere notable for low brightness contrast and high visibility.

PLEXIGLAS aids design and installation, too. Lightness and strength mean easy erection with fewer, lighter supports. Resistance to breakage and discoloration assures low-cost maintenance. And the variety of translucency-grades in flat, patterned, or corrugated material, coupled with the ability of PLEXIGLAS to be formed readily and economically to almost any desired shape, gives almost unlimited scope to fixture design.

◀ PLEXIGLAS is used for both diffusion and reflection of light in the General Electric Company Board of Directors' Room, New York City. White translucent panels in the 9-foot-square fixtures diffuse perfectly the light from 18 Slimlines mounted only 2½" from the acrylic plastic surfaces. Lightly sanded on the outside, the panels also act as diffuse reflectors for indirect lighting from hanging fixtures that are used when the main lighting is not needed. Fixtures designed and installed by The Frink Corporation, Long Island City, New York.

approved the New PLEXIGLAS Lighting..."



▲ PLEXIGLAS ceiling lighting fixtures in the Directors' Room of Cleveland's Bank of Ohio produce an average illumination of 75 footcandles on the conference table. Each fixture measures approximately 6 x 8 feet and consists of four corrugated bottom diffusing panels with curved side panels formed from 12" strips of flat material. Ten 96" 300MA G.E. Slimline and two 40-watt fluorescent lamps (mounted at right angles at the ends of the Slimlines) illuminate each fixture. All lamps are 3000°. Fixtures installed by Bell Electric Company. Design consultants: W. E. Conley, General Electric Co.; John Liston, George S. Rider Co.; W. A. Mize, Cleveland Electric Illuminating Company.

TELL US ABOUT YOUR PROBLEM

We will be glad to work with you on specific lighting applications. Write us today. Let us show you how PLEXIGLAS can provide the best answer to your lighting problem.

PLEXIGLAS is a trade-mark, Reg. U. S. Pat. Off. and in principal foreign countries.

CHEMICALS FOR INDUSTRY

ROHM & HAAS COMPANY

WASHINGTON SQUARE, PHILADELPHIA 5, PA.

Representatives in principal foreign countries

Canadian Distributor: Crystal Glass & Plastics, Ltd., 282 St. Helens Avenue, Toronto, Ont.

6' SPACING OF ROWS GIVES EVEN LIGHTING
OPEN FIXTURE REDUCES MAINTENANCE COST
40 WATT G-E LOW BRIGHTNESS FLUORESCENT LAMPS
NOTE 1 GENERAL ELECTRIC LOW BRIGHTNESS LAMPS GIVE SAME AMOUNT OF LIGHT AS STANDARD 40 WATT
NOTE 2 GENERAL ELECTRIC LOW BRIGHTNESS LAMPS START INSTANTLY

How to get more top-notch lighting jobs on your board

Here's a special lamp for special jobs—the General Electric *low-brightness* lamp. It offers the kind of advantages that are bound to help bring in more orders for top-quality lighting jobs.

REDUCED GLARE

These 40-watt T-17 fluorescent lamps give as much light as standard 40-watt T-12 G-E lamps, but deliver it from a much bigger tube. With low-brightness lamps reflected glare is reduced.

EASY MAINTENANCE

Low-brightness lamps are frequently used in open troffers and fixtures without cross louvers. That makes them easy to get at for replacing and cleaning. For example, at the Flossmore school in Chicago, janitors clean the lamps with a vacuum cleaner attachment as they walk down each row.

INSTANT START

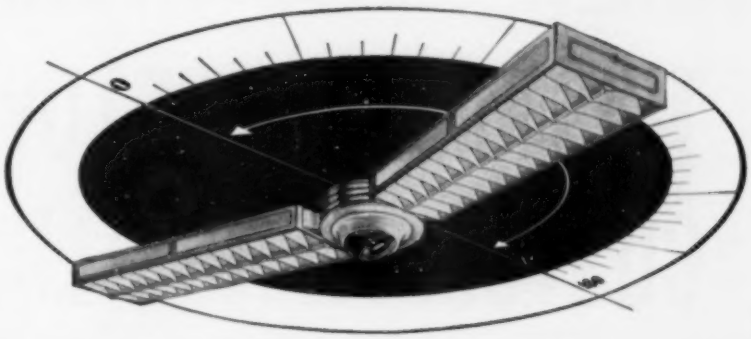
General Electric low-brightness lamps start instantly—and customers have no starters to maintain.

You'll find low-brightness lamps a good buy for schools, offices, and quality shops that want fine lighting. For more data, call your nearest General Electric lamp district office.

GENERAL ELECTRIC

Now! Real Lighting Flexibility!

PLEXOLINE is a new idea—an imaginative engineering creation that permits, for the first time, truly unlimited fluorescent lighting patterns at mass-production costs. PLEXOLINE is an ingenious system of related linear sections and circular accent units. Used in combination, these elements are capable of achieving curves, circles, any angular arrangement, rectangles, and straight continuous runs. Used individually, each element is complete in itself.



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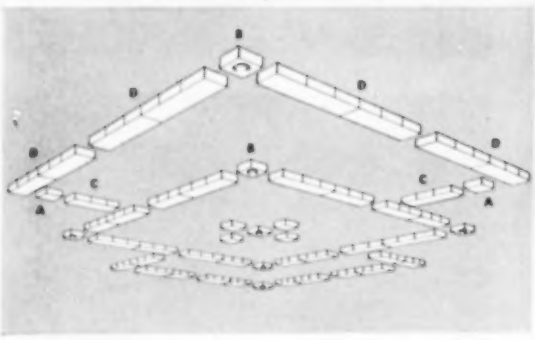

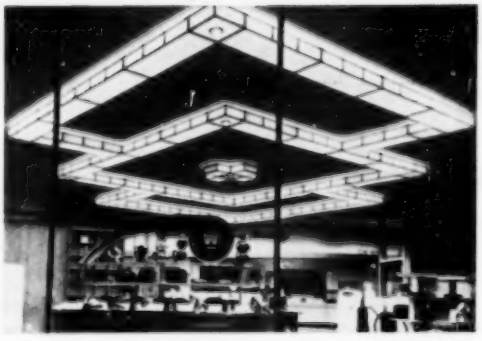

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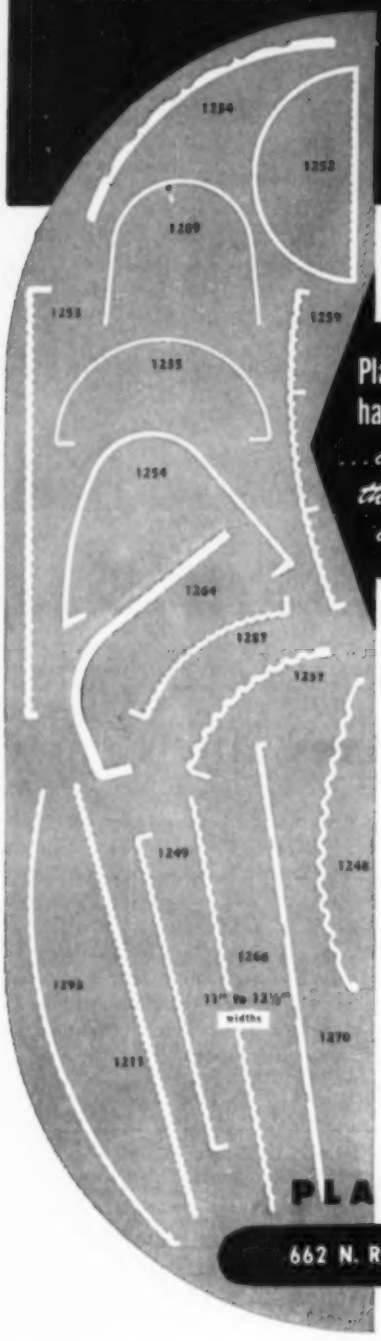

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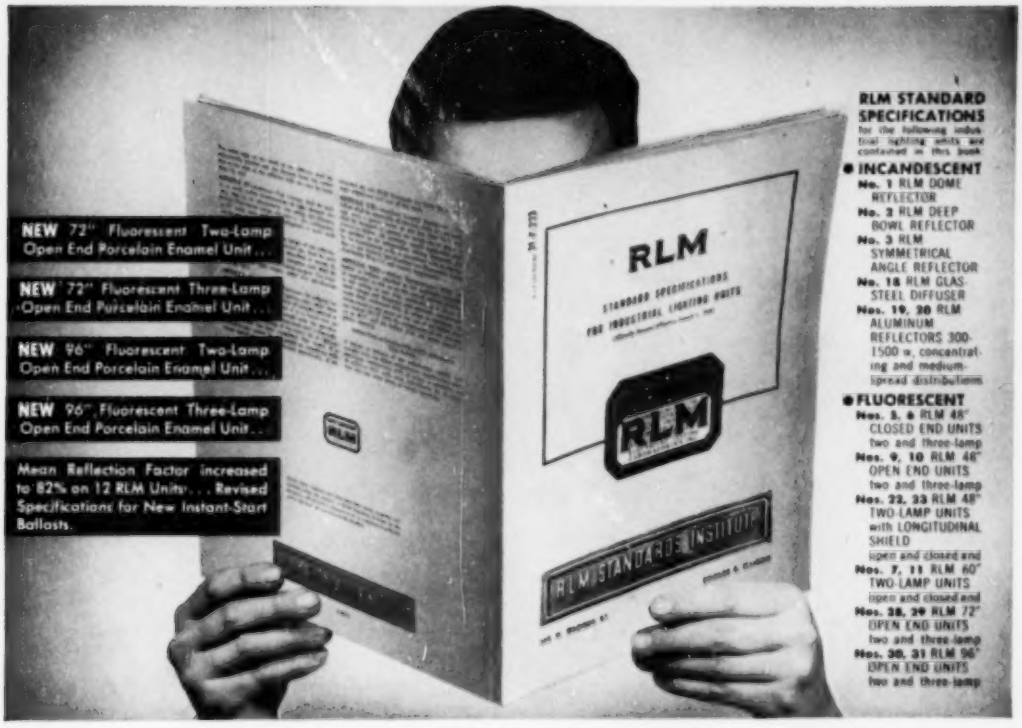
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This new Westinghouse lamp, containing equal amounts of krypton and argon gases, produces 4860 lumens . . . six percent more light than the 85-watt lamp which it supersedes . . . at a total electrical increase of only three watts.

The size of the lamp remains the same . . . 5 feet long and 2⅛ inches diameter . . . and operates in either 85-watt or the old 100-watt lighting equipment. The 90-watt lamp is 17 percent more efficient than the 100-watt, all-argon lamp which the 85-watt lamp had replaced . . . and it triples the light output of a 100-watt incandescent bulb.

The new 90-watt lamp is available in the five standard shades of white. For more information about this new cost-cutting lamp, call your Westinghouse Lamp Distributor or write to Lamp Division, Westinghouse Electric Corporation, Bloomfield, New Jersey.

Leading the Field
Since the war, Westinghouse has scored 35 firsts in producing new and improved light sources.

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